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The relationship between the digital experiences of children and teachers and their use of online websites in the assessment of Maths in Primary Schools

Skoulikari, Eleni Anna

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The relationship between the digital experiences of children and teachers and their use of online websites in the assessment of Maths in Primary Schools

Eleni Anna Skoulikari

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The material presented here for examination for the award of a higher degree by research has not been incorporated into a submission for another degree.

Candidate's signature:

Declaration of authorship

I am the author of this thesis, and the work described therein was carried out by myself personally.

Candidate's signature:

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Ελεάννα

Abstract

Background: There is extensive research on the use of technologies in educational assessment in higher education, but not in primary schools. Recently the Department for Education has been exploring a new way of assessing maths knowledge online for children in Key Stage 2.

Aim: The overall aim of this thesis was to examine the relationship between how children and teachers use Online Maths Websites (OMW) based on their digital experiences through the lenses of Digital Natives and Immigrants.

Methods: This thesis started with an exploratory qualitative study, which identified the most common use of technologies in assessment in primary schools. The next three studies of the thesis explored the relationships between the digital experiences of children and teachers and the ways they use the OMW. The first two studies based on self-report while the third study used a combination of self-reported and usage data.

Main findings: Study 1 identified the use of OMW as the most common use of technology in assessment in primary schools. Studies 2 and 3 found that the digital experience factors that are positively linked to children's use of the OMW were mainly their confidence and computer skills. Both studies added evidence to previous research arguing that there is no specific generation of children experts in the use of technologies. Study 3 also revealed that four out of five measures of self-reported and usage data were linked positively. Study 4 showed that digital native and immigrant teachers do not differ as much as authors believe they do.

Conclusion: Children's and teachers' digital experiences should not be taken as a given, neither as digital natives nor immigrants. Their technological skills should be researched from a combination of usage and self-reported data. Teachers and parents should work together to build children's technological empowerment.

1. Introduction

Information and communications technology (ICT) has become an important part of teaching and learning and it is embedded in the UK national curriculum of primary schools in many different ways, from the use of whiteboards to the introduction of the subject of coding. Although ICT has been integrated in teaching at an ever increasing rate since the introduction of the first computers in classrooms in 1992 (Somekh, 2000), its use in relation to educational assessment has remained low and focused mainly on formative rather than summative assessment (Spector et al., 2016). There is a lot of discussion and debate regarding whether educational assessment should change in order to follow the changes happening in teaching and learning with the use of ICT. It is clear that the Department for Education (DfE) has been working towards these kind of changes and this is evident in its latest framework for the introduction of an online on-screen assessment for primary schools, specifically the multiplication tables check (MTC) assessment of pupils in Year 4 (Standards & Testing Agency, 2018).

The introduction of this new test will be part of the pupils' summative assessment from 2019/20 and is the first assessment to use computers and laptops for summative purposes. The Standards and Testing Agency (2018) has dedicated a section about diversity and inclusion in their report and they claim that the *"MTC test should provide opportunities for all pupils to achieve, irrespective of gender, including pupils with special educational needs, pupils with disabilities, pupils from all social and cultural backgrounds and those from diverse linguistic backgrounds"* (p.13). However, they do not state how the MTC test is going to address the issue of different backgrounds. The report states that the specific test has gone through trials in a number of schools, but no results have been published in relation to these pilots and there is limited previous research to indicate whether the digital experiences of children are linked to how they use digital assessment tools (such as the MTC) and how they perform on them. In addition, there is little research concerning whether teachers are familiar with the use of technologies based on their digital experiences and are using them in educationally productive ways. Thus, there is a gap in terms of the existing knowledge in relation to how children interact with online assessment and how teachers handle these tests.

The current thesis investigates the relationship between the digital experiences of children and teachers and their use of online websites for the assessment of maths in primary schools. The introduction presents the background information and the rationale for the research questions. It starts with the importance of educational assessment and the fact that it has not been changed over many years. Then, it discusses whether and how technology could significantly change assessment methods, the recent reforms that the Department for Education has made in the assessment of Maths and what the most recent research shows in terms of the use of technologies in the assessment of Maths in primary schools. The theoretical frameworks that are used for the thesis are discussed followed by the aims of the thesis and the methods used in studies 1-4.

1.1 Educational Assessment

Assessment is considered one of the most important aspects of an educational system, as it offers information on learning, guides the progress and performance of students and illustrates understanding of the curriculum (Oldfield, Broadfoot, Sutherland & Timmis, 2012; Black & William, 1998; Harlen, 1994; Wragg, 2003). As Black and William (1999) argued, "*Assessment is one of the most powerful educational tools for promoting effective learning. But it must be used in the right way.*" (p.2). By saying the right way, they mean that assessment should be used by teachers to help them organise their teaching according to their pupils' needs and with the aim to raise the pupils' achievement. The purpose of assessment and its use are significant elements in the planning of teaching.

Assessment can take different forms depending on the adjective word that accompanies it. Some of the most common forms of assessment in the educational domain are the following; formative, summative, diagnostic, evaluative, and they are defined by the reason and the use of the educational assessment. This thesis focuses on formative and summative assessment, because those are the two main forms of assessment used in primary schools. It is worth mentioning that formative assessment is also known as "assessment for learning". Mansell and James (2009) describe formative and summative assessment as:

"Formative is the use of day-to-day, often informal, assessment to explore pupils' understanding so that the teacher can best decide how to help them to develop that understanding." (p.9)

Summative is the more formal summing-up of a pupil's progress that can then be used for purposes ranging from providing information to parents to certification as part of a formal examination course." (p.9)

However, there are some doubts regarding the current practices of assessment and whether they link to the requirements of today's students or they are outdated. Researchers argue that since the world is changing rapidly and with it, the knowledge and skills that students need, education systems should respond effectively to these social, political, environmental and economic challenges by trying to reform their current practices (Schwartz & Arena, 2009; Broadfoot, 2007; Gee & Shaffer, 2010; Griffin, McGaw & Care, 2012). The main purpose of assessment, according to Oldfield et al. (2012), is to support learning, but since the world is changing and developing in many different ways, such as with the integration and the daily use of technologies, and assessment practices remain the same, this purpose is not fulfilled.

The change that demands assessment to illustrate the ways that students learn today constitutes a challenge for people working in the field of educational assessment. In particular, it is difficult to find specific ways to translate the ideas of change into practice, as new practices should not just be a replication of the old activities. New assessment activities should support students' learning with the use of digital devices and at the same time should be based on educational theories (Claxton, 2007).

The roles that students take outside the classroom as they participate and collaborate in learning online, and the skills they develop as they use digital technologies in their everyday life (Faliagka, Tsakalidis & Vaikousi, 2011; Vryzas & Tsitouridou 2002) could be integrated in their education at school. More specifically, the use of technologies in educational assessment could work effectively under an organised and well-planned assessment practice (Oldfield et al, 2012). This combination of technologies and assessment has many different terms in research, but the most common is e-Assessment, or Technology Enhanced Assessment (TEA).

According to the e-Assessment Glossary, which was published by the Joint Information Systems Committee (JISC) and the Qualifications and Curriculum Authority (QCA) in 2006, *"e-assessment is defined as the end-to-end electronic assessment processes where ICT is used for the presentation of assessment activity and the recording of responses. This includes the end-to-end assessment process from the perspective of learners, tutors, learning establishments, awarding bodies and regulators, and the general public"* (p.4), while Technology Enhanced Assessment (TEA) is defined as the use of technology to extend or add value to assessment and feedback practices (JISC, 2010).

1.2 Technology in Educational Assessment

There is no doubt that Information, Communication Technologies (ICT) and digital devices have increased in both education, and everyday life and as a result learning today is migrating from teachers, books and schools to a combination of virtual and physical interactions that can be controlled by learners (de Castel & Jenson, 2004). The world is changing fast and there is a demand that needs education to change too in order to adapt to the requirements of the 21st century. According to the ESRC report (2012), education nowadays is not taking full advantage of the technology that exists in our everyday life and, teaching and learning has not been transformed yet.

While there is a great interest not only by researchers, but also by policy makers and teachers about the interplay between technologies and assessment, there is plenty of literature on the topic (Oldfield et al., 2012; Griffin et al., 2012; Scardamalia et al., 2012; Attwood & Radnofsky, 2007; DiCerbo, 2014), but little research on actual implementation, particularly at the level of primary schools. As Bennett (2002) argued, *"the incorporation of technology into assessment is inevitable"* (p.14), but changes in education systems are also complex. Thus, it is justified that there are no huge changes on assessment practices.

Oldfield et al. (2012) in their review of technology enhanced assessment sum up the most common benefits and challenges that technology could offer to educational assessment based on the work of Pellegrino and Quellmalz (2010), Whitelock and Watt

(2008), Winkley (2010), JISC (2010) and Schwartz and Arena (2009). This section introduces those benefits as they were discussed in the articles above.

- Immediate feedback

Technology can offer students *"real-time"* feedback, which can reduce misunderstandings and confusion about a subject and inform the next steps of teaching appropriately. The feedback could come either from a teacher, a classmate or even from someone outside the school community through a blog, or a website.

- Learners' autonomy, agency and self-regulation

The use of ICT can also support students to have a deeper reflective process of learning by offering ways of self-evaluation and more personalised responses to their work. For instance, Dearnley et al. (n.d) after a five year study on mobile learning and assessment stated that mobile devices give the opportunity to the student for in moment reflections that are captured in many different forms, like written, audio, pictures, and can be used later on to stimulate the students' memory and engage in deeper reflective processes.

- Collaborative learning

With the use of technology collaborative learning could also evolve through peer assessment and students' responses to a question or a topic. The process of co-evaluation could support knowledge building between the learners. Technology offers many different solutions for online collaborative learning, from university online platforms, to blogs and forums where people can ask questions and exchange knowledge and ideas on specific topics of interest.

- Authenticity

Technology provides authentic ways of assessing complex and challenging skills of the 21st century, like problem solving and decision making, which are difficult to evaluate using traditional methods of educational assessment. For example, Schwartz and Arena (2009) claimed that video games could be a way of assessing decision making, as students can experience the consequences and effects of their choices in real time.

- Wider range of measurement

The use of technology offers the opportunity for the data of an assessment practice to be demonstrated and analysed easily and in many different ways and forms. For instance, assessment data, instead of just being in the form of a grade or a percentage, they can also be displayed on diagrams that illustrate the students' progress through the passage of the time.

- Flexible and appropriate responses

Practices of assessment that make use of new technologies can offer feedback in a wide range of different formats, ways, time and locations. In that way technology offers educational assessment the elimination of time and place (Santos et al., 2011).

- Teachers' workload

Marking, regulating and storing students' data with the use of technology becomes easier and less time consuming for teachers, but also more environmentally friendly, as it diminishes the use of paper related to educational assessment.

- The assessment experience/ students' engagement

Technology offers richer and more personalised assessment activities to students and that makes the assessment experience for students more pleasant. For example, Hwang and Chang (2010) conducted research on a formative assessment mobile learning approach and found that students were more motivated and engaged during the assessment activity, as they were using their mobile phones and the whole experience seemed more favourable to them.

- Formative and summative assessments

Formative and summative ways of assessment can be combined with the use of technology. More specifically, new technologies allow formative assessment to be integrated into teaching and inform the students' summative assessment. For example, digital technologies can monitor learners' way of thinking, as they can record the students' decisions while they are solving a Maths problem.

- Assessment validity and reliability

Linked to the previous possible benefit, the combination of formative assessment with instruction can offer teachers more data about a student's performance on a regular basis and in that way, teachers can have more data to inform their decisions about the student's summative assessment. Formative practices can become more regular, the evaluation of the student can be based on a large amount of data regarding attainments and learning targets and that can raise the validity and reliability of the assessment significantly.

- Diagnosis of learning problems

The fact that technology has the chance to track the students' way of thinking and thus, their learning in general, can be an important element in the early diagnosis of learning problem, difficulties or misunderstandings (Charman & Elmes, 1998).

- Students with specific learning difficulties (SpLD/Dyslexia)

Regarding the self-assessment of students with specific learning difficulties, digital technologies offer them many ways to facilitate their learning; using spell check, audio recording and image snapshots, which can be used to stimulate memory and inform the students' self-assessment (Dearnley et al., n.d).

- Bridging learning theories and assessment

Broadfoot (2017) argued that one of the biggest issues with assessment is that, in most cases, it is not clearly linked to learning theories, but the use of technologies in assessment practices can link assessment to learning. She argued that the fact that technology can offer different ways of collecting and understanding students' data, and also more personalised feedback with tasks that are engaging and allow students to take part in their assessment are all aspects that allow a clearer link between assessment and educational goals and purposes. She claimed that technology based assessments have greater potential in supporting learning than some of the outdated old assessment techniques that are still used today.

It has to be mentioned here that all authors who wrote about the advantages of technology use in assessment stress that not all the aforementioned elements guarantee benefits. It always depends on the way that a technology is introduced and used in an assessment practice that makes it effective and successful. Digital technologies are not panacea. On the contrary, their integration in education is quite complex and requires a very well organised plan that will take into consideration the learning targets, the needs and background of the students, the appropriateness of the technological tool they are going to use and the way that they are going to integrate it in the lesson.

However, even if the integration of technology into assessment is accompanied by many potential benefits and deemed as inevitable for the future (Bennett, 2002), it is widely agreed that it is also an educational element that is very difficult to change (Timmis et al., 2012; Broadfoot, 2007; Schwartz & Arena, 2009). Research indicates that there are many challenges and barriers regarding e-Assessment and they could be classified in the six following categories (Mogey, 2011; Whitelock & Watt, 2008; Ripley, 2007; Oldfield et al, 2012; Timmis et al, 2012; Facer, 2012; Bevan, 2011; Mogey, 2011). Some of the most important challenges are discussed briefly in the following section.

- Educational assessment is publicly accountable and heavily controlled

Changes on educational assessment could cause important consequences on the students' development and that is the main reason why especially summative assessment is more difficult to change than formative assessment. Every time a new method of assessment is implemented into schools, there is a risk of failure. The risk becomes relatively high when the result of the assessment activity can affect the learner's future. In addition to that risk, there is also the risk of the investment cost, which concerns the software, and hardware that should be bought in order the teachers to have the necessary equipment, training and support to improve their assessment techniques.

- Concerns in relation to validity and reliability in terms of assessment equivalence

Especially when the assessment activity takes place online, there are concerns regarding the identity of the user that takes the exam. There is no way of invigilating students online and that gives them the opportunity to commit plagiarism, or cheat. Furthermore, when summative assessment is concerned, there is a difficulty in assessing collaborative work, as there is no guarantee that all students put the same cognitive effort for the work. In addition, it is quite difficult to keep the same standards for all students and ensure that they are all equally assessed, in case the questions of a test are selected randomly from a question bank.

- Ethical issues

One of the main challenges regarding technologies in educational assessment is the data management and ownership. The digitalisation of data raises concerns regarding the way that students' records are collected, used and stored. It is questioned whether the parents and students will consent to have their personal data online, if they will have access and control of it and who will be responsible for the online data.

- Teacher training

Many teachers have reported that they have little, or no experience of using technological equipment, which lead to psychological barriers in terms of using technology into their teaching (Bevan, 2011). Regarding assessment, there is no specific training on the use of new forms of e-assessment and it depends on the teacher and his/her knowledge, comfort, preferences and previous experiences regarding digital technologies and how to use them effectively into teaching. In addition, there is no widespread awareness of relevant techniques that teachers could use, as there are no specific ways to share the exceptional and innovative techniques in relation to technology-enhanced assessment. Most of the times the efforts are individual initiatives that are not shared.

- Difficulties in scalability and transferability of the assessment methods

Especially in higher education where the different departments assess their students in different ways, there are difficulties in setting specific criteria for the assessment and thus, the scalability and transferability of those techniques is more complicated. Furthermore, due to the digital divide, learners may have not the appropriate equipment to follow the teachers' feedback when they are not at school or university and therefore, it is quite difficult for teachers to apply the same techniques in institutions of different development.

- Lack of relevant policies

Currently, there is no specific official guidance by the government regarding the use of technologies in educational assessment. In addition to that, most institutions do not have the appropriate physical spaces that can cover the needs of technologies into assessment. For example, when students take an exam using computers, or laptops that should be connected on the Internet, the school/institution should have the right number of devices, rechargers and connectivity that will be able to support all the computers at the same time. However, as Broadfoot et al. (2014) claim, *"the dangers of not engaging with the potential of e-assessment are arguably much greater*" (p.21) stressing that the advantages of technology enhanced assessment are more than the challenges and risks and the introduction of these kind of assessments are worth investigating further.

1.3 Reforms in Educational Assessment and Maths in Primary Schools

However, the government recognises the need to change the way assessments are held in schools today and this is evident from the reforms that have taken place over the last few years in the national curriculum, especially in primary schools. One of the biggest reforms happened in 2014/15 when the Department for Education decided to remove the system of 'levels' which was used until then to report children's attainment and progress. The main reason why they decided to make this change was to allow more freedom and flexibility for teachers to plan and assess their students.

The second biggest change after the removal of the ‘levels’ was the introduction of the very first online assessment; the multiplication tables check (MTC) assessment. The Schools Minister Nick Gibb in a press release by the Department of Education stated that multiplication tables are a very important part of mathematical knowledge and necessary for all children who need to perform long multiplication and division, and this is the main reason why they decided to introduce the Multiplication tables check assessment from 2020 (Department for Education & The Rt Hon Nick Gibb MP, 2019). It is worth mentioning that there was long discussion about the implementation of this test. The first time that Schools Minister Nick Gibb announced the news about this test was in October 2015 in an interview with Laura McInerney for Schools Week, while the former education secretary Nicky Morgan confirmed it in another interview with Freddie Whittaker in January 2016. She announced that primary schools would try the on-screen times tables tests in the summer of 2016 before it is introduced across England in 2017. Nevertheless, this plan was delayed, and the check was originally planned to be taken by Year 6 pupils at the end of the 2018/19 academic year alongside the national curriculum Standard Assessment Tests (known as SATS). However, after it was trialled in 80 primary schools with more than 3,000 pupils, it was announced that it would be aimed at pupils in Year 4 in order to determine if they can recall fluently their multiplication tables.

More specifically, the Multiplication Tables Check (MTC) assessment framework published by the DfE in November 2018 specifies that the check will be delivered as an online on-screen assessment which will last less than 5 minutes for each pupil and will be scored automatically. The MTC is available as a voluntary assessment in the 2018/19 academic year and schools can choose if they want to try it with their students. The MTC will be statutory for all schools in England from the 2019/20 academic year. The check will be delivered on-screen, either on a computer or a tablet, and it will need an internet connection. Its content will include questions on multiplication up to 12x12 and the pupils will have a 6-second time frame in order to answer each question. The DfE has not published any reports based on the results of the trials, but the decision to make this online check compulsory for all schools in the near future is a very important step towards the implementation of online assessments in primary schools. The MTC will be the very first official summative assessment that will be delivered with the use of ICT and it makes research on the topic even more timely.

1.4 Recent research on the use of technologies in Maths assessment and online testing

The existing literature and research refer mainly to practices that use technologies in assessment for secondary schools (Leigh-Lancaster, 2010; Sangwin, Cazes, Lee & Wong, 2009) and mostly for Higher Education (Angus & Watson, 2009; Dermo, 2009; Buzzetto-More & Alade, 2006; Dearnley et al, n.d), but there are very few studies regarding primary schools (e.g. Sandene et al, 2005). Previous research on the use of technologies in the assessment of Maths in primary schools has shown that the interplay between the two is mostly positive. However, a common theme over studies is that the factors that influence the relationship between the use of technologies and performance in Maths are so varied that there is not enough evidence to determine a clear link between the two.

An example of this is research by Kodippili and Senaratne (2008) who conducted a study in order to determine whether the use of a computer-generated interactive mathematics homework would be more effective than traditional instructor-graded homework. They found that there was not enough evidence to support the hypothesis that the students who used the online homework (MyMathLab) had an overall better performance than the students who used the paper-based homework. However, they noticed that the students who completed their homework online had higher success rates than the ones who used the paper-based homework (the mean score of MyMathLab was higher than the mean score of the paper based homework, but the p-value was 0.0638). They suggested that since technology is an essential tool in teaching and learning and their research showed that there was a difference regarding the success rates, the use of the online homework can have potential benefits for both teachers and students.

Roschelle, Feng, Murphy and Mason (2016) conducted a randomized field trial to investigate whether an educational technology intervention would increase the learning of Year 7 students' maths. They combined online homework with teacher training and they found that the intervention had positive results in terms of students' performance in maths. More specifically, the results showed that the students who completed their homework online had significantly higher scores on an end-of-the-year assessment than the students who completed their homework using traditional methods like textbooks. It was also shown that the greater benefit of the intervention was for the students who had lower mathematics scores. However, the research was conducted at a province in Maine (US) that provides laptops to all seventh-grade (equivalent to year 8 in the UK) students and this is something that does not happen in all countries and cities. However, there is supporting evidence from research conducted in the UK in primary schools, where researchers assessed a tablet-technology maths intervention and found significant strong and sustained learning gains after the intervention, especially for low-achieving students (Outhwaite, Gulliford & Pitchford, 2017).

Although the above intervention detected higher improvement for students with lower scores in mathematics, Faber, Luyten and Visscher (2017) examined the effects of a digital formative assessment tool (Snappet) in relation to the students' achievement and motivation in mathematics, and they found that the students who benefited the most were the ones who were high-performing students. Their results also showed that the Year 3 students who used the digital assessment tool to a greater extent (total number of tasks completed online) showed better performance than the students who used it less. However, as the authors stress, it cannot be argued that the use of Snappet was what caused the effect of better performance, as it might be that the students who used the digital tool were more motivated than the ones who did not. In addition to this, Ingram, Strand and Sarazin (2015) explored the use of Mathletics at Key Stage 2 and they found that the schools where children completed at least 3 online activities on a weekly basis had more students who made a progress of at least 2 levels.

Haelermans and Ghysels (2013; 2017) work also supports the fact that individualised online practice of maths at home can substantially and significantly improve the students' performance. They conducted a two stage experiment where they used a digital practice tool for maths with Year 7 students. The first stage of the experiment showed that the students who used the individualised digital tool had a better performance in their numeracy scores, and the more they used it, the better their performance would be. However, the second stage of the experiment where the students had not an individualised use of the tool, but free access to all tasks, and they spent more time on the tool, the effects on students' performance disappeared. The authors concluded the effectiveness of the tool at the first stage of the experiment was mainly linked to the individualised aspect of the use, rather than just the use of it, or the time spent on it.

Research conducted by De Witte, Haelermans and Rogge (2015) regarding the use of computer assisted instruction programmes and students' outcomes found that the use of the digital programs in secondary schools has a positive effect on the students' performance. More specifically, their literature review showed that the schools who use the digital tools more frequently are the schools with lower mathematics scores and the use of those tools is a way for the schools to improve the learning outcomes of their students. The fact that the students use the digital tools more and they get higher marks too suggests that the use of the digital tools is effective and it is also linked to the extent of how much it is used. The results are also supported by the research of Koedinger, McLaughlin and Hefferman (2010) who found that greater use of a web-based math tutoring system is associated with better performance of the students.

However, it is interesting that a report based on the Organisation for Economic Cooperation and Development's (OECD) (2015) Programme for International Student Assessment's (PISA) periodic testing program on student performance has found some different results (Rutkowski, 2015). More specifically, the report supports that across the students of the OECD countries who do not use computers and different technological tools in mathematics have a better performance in both paper-based and computer-based assessments. The report argues that even the skills that students need to use a computer do not make a big difference to their performance in maths. The results were the same even when they accounted for differences in the socio-economic status (SES) of the children. The only exceptions were detected in Belgium, Denmark and Norway, where the researchers found a positive link between the children who were using computers in maths lessons and their performance in the computer based assessments, especially when they accounted for differences in SES.

Another project, which was part of the National Assessment of Educational Progress (NAEP), investigated the use of technology in the assessment of maths and focused on issues of measurement, equity, efficiency and operations (Sandene et al., 2005). The project included more than 2000 children in grades 4 and 8 who took maths tests online and on the paper. In order the study to be as informed and complete as possible, the researchers also gathered data in relation to children's digital experiences; access, use and attitudes. In terms of measurement, the findings revealed that the students' grades on the computer-based tests tended to be around 4 points lower than the grades of students who did the same maths tests on paper. The difficulty of the computer-based tests also seemed to be higher on the computers than on paper, as there were more students (5%) who got the right answers on the paper based tests. In terms of equity, the researchers analysed the background information gathered for the children (gender, race/ethnicity, parent's education level, region of the country, school location and type) and found that only parent's education level impacted the difference on students' performance on the computer vs on the paper tests. The students who had at least one parent who graduated from college scored higher on paper than on computers. The background data also showed that almost all students had access to technology at home and school and thus, they had some form of familiarity with technology. However, the results of the project also revealed that the performance of students on the computer-based tests was partly dependent on how the students' familiarity with technology.

Although the majority of research related to the use of technologies in the assessment of Maths is focused on secondary education. There is a study which investigated exploring the same relationship in primary schools and yet, the very first on-screen summative assessment that the Department for Education has introduced in the UK National Curriculum is aimed at children at Year 4. One of the reasons behind this lack of research is that there is a widespread belief that children today are experts in using technology because they have grown up with it. This argument was firstly developed by Tapscott in 1998 with the net generation and it became very popular when Prensky (2001) discussed the concept of Digital Natives and Immigrants.

1.5 Theoretical Frameworks of the thesis

This thesis is based on two theoretical frameworks. The first is the Educational Digital Divide model by Hohlfeld et al. (2008) which argues that even if the digital divide with regards to access to ICT and the Internet has decreased or even disappeared, this does not mean that all children can use technologies in the same beneficial way. The next stage after access is how it is actually used by teachers and students in the classroom. The third and last stage is using it to empower students to use technologies in ways that can help them improve their life. This framework is closely related to the investigation of the children's and teacher's digital experiences and the ways that they use online maths websites for assessment purposes.

The second theoretical framework is the concept of Digital Natives and Immigrants (Prensky, 2001) which is one of the most well-known theories amongst educators regarding how children and teachers use ICT and the differences in their approaches to technologies in terms of teaching and learning. The specific concept argues that all people born after 1980 are Digital Natives; experts in the use of technologies because they were raised with them. People born before that are considered Digital Immigrants, as they had to learn how to use technology at a later stage of their lives. At the time that this framework was developed the majority of teachers belonged to the generation of Digital Immigrants, while all the students were considered to be Digital Natives. Prensky (2001) argued that because teachers were Digital Immigrants they could not teach their Digital Native students in appropriate ways and thus education needed major changes and reforms.

It is seventeen years since this concept was first introduced and there has been a lot of debate in academia in relation to it, but according to Judd (2018), the interest for this concept has remained strong over the years and there are still people who believe it is valid. This is evident not only in recent educational blogs that support the idea that digital natives exist and teachers need to rethink education for them (Adobe Communications team, 2018), but also in the results of the first study of the thesis, where teachers talked about technology use as a generational issue. In addition to that, the existence of these terms are also shown in their use in marketing, where both digital native and immigrants are used in academic papers without any critical discussion or consideration of what these terms mean and whether they are valid (e.g. Filho, Gammarano & Barreto, 2019).

1.6 Aim of the thesis

While most of the research in this area explores the use of technologies in relation to factors like the socio-economic status and profile of children and their families (Blackwell, Lauricella & Wartella, 2014; Espinosa, Laffey, Whittaker & Sheng, 2006; Jackson, Zhao, Kolenic, Fitzgerald, Harold, & Von Eye, 2008), or children's safety online (Holloway, Green & Livingstone, 2013; Livingstone et al., 2014), the current thesis is exploring the relationship between the digital experiences of children and teachers and their use of online websites for the assessment of Maths in primary schools. The thesis is trying to bridge the gap that exists in the literature regarding technologies in assessment at the primary school level. The specific research is aiming to offer valuable knowledge and information regarding whether the technological experiences that children and teachers have at home are linked to how students perform and how teachers use online maths websites in order to inform relevant educational reforms like the introduction of the MTC. The fact that the Department of Education made the first step towards methods of assessment with the use of technology makes research like this necessary.

The findings of this thesis can inform future educational practice, not only in policy (like the implementation of the Multiplication Tables Check), but also the ways teachers, parents and the Online Maths Websites can help children to become technologically empowered. It is important that any changes and reforms that happen in the Educational sector by the Department of Education should be guided by current research. Although changes such as the implementation of technologies in summative assessment might seem the right way forward and they could be considered pioneering, it is essential to make sure that all students will be equally prepared for those changes and there will be no inequalities or differences based on their previous digital experiences.

The next chapter discusses the theoretical frameworks that the thesis has adopted in order to examine the research questions and the aims that were mentioned above. The first theoretical framework is the Educational Digital Divide by Hohlfeld et al. (2008) and the second one is the concept of Digital Natives and Immigrants, which was developed by Prensky in 2001.

1.7 Methods used in the thesis

The methods that were used for each study were based on the literature and the aims of the thesis. More specifically, the first study of the thesis was exploratory with the aim to gain a better understanding of the current practices of technology use in assessment in primary schools. The fact that there is no specific document reporting how teachers and students use technology for purposes of assessment in schools made the first exploratory study of the PhD necessary. The investigation of pupils' and teachers' experiences and perceptions on the use of technologies in assessment helped the researcher identify the most interesting aspects of the topic that can be explored further in the next studies of the thesis. The first study aimed to specify whether teachers and students use any kind of technology for formative or summative assessment, what they think of it, and whether the integration of technology in assessment would affect students' feelings and performance. Since the aim of the study was to gain an in depth understanding of the use of technologies in assessment, the method that was considered the most appropriate for this purpose was the interviews. The use of interviews can give access to meanings, perceptions and constructions of reality of the participants and it is a tool that helps the researcher understand the participants (Punch, 2009). In addition, the use of interviews allowed the researcher to get children's thoughts and opinions in more detail. Understanding children's point of view on the specific topic was one of the most important aspects of the first study. For that reason and in order the researcher to reduce biased answers of the children and increase the possibilities of gathering children's actual feelings and thoughts, the interview protocol for the children included two activities; the use of two collages with photos related to paper based and technology based assessment and a role play activity (Cohen et al., 2011). The researcher developed two interview protocols for this first study, one for the teachers and one for the children.

The results of study 1 revealed that one of the main factors that is linked to how children use technologies for purposes of assessment is their digital experiences. The qualitative approach that was taken for study 1 allowed for a deeper understanding of the situation that informed the formation of the hypothesis of study 2. The second study of the thesis focused on the relationship between the digital experiences of children and their use of Online Maths Websites (OMW). The use of OMWs was the most common use of technologies for the assessment of students and was mentioned by both the teachers and children participants of study 1. Thus, study 2 needed to measure children's digital experiences at home and examine its relationship to the use of OMWs. The method that was considered as the most appropriate to investigate this relationship was the use of a questionnaire that would allow the researcher to measure children's use of digital technologies and OMWs. Due to the fact that the literature on the topic did not provide any previously validated questionnaires that could measure digital experience and OMW use, the researcher developed a new questionnaire designed for the purposes of this study. The process that was followed for the development of this questionnaire and the measures used in it are discussed in detail in the method section of study 2 (see p.114).

However, one of the main limitations of study 2 was the fact that all the data gathered through the questionnaires were based on children's self-reports and not usage data of the OMWs. Previous research on the relationship between self-reported and usage data of Internet use has revealed that the best way to get a more complete idea of children's use of technologies is to combine their self-reported data with usage data. Junco (2013) collected usage and self-reported data from university students to examine how they use Facebook in terms of the time they spend on the website and the number of logins. His results also showed moderate relationships between his measures and he concluded that if researchers want to improve the external validity of their results, then they should attempt to collect and relate self-report and usage data. This was also supported by another more recent study conducted by Wilcockson, Ellis and Shaw (2018) aimed to examine the value of self-report data in relation to use of smartphones. They also found that the self-reported data were not correlated to the usage data of usage by the participants.

These findings raise a question in relation to the validity of self-report data and whether it can be trusted on its own or needs to be matched by usage data in order to offer valid results. It is worth mentioning that collecting self-report data by children has been criticised on the basis that the children might not be able to accurately report on their experiences (Beck et al., 2012). However, this seems to be more of a general issue of self-reported data in relation to technology use and not just an issue that is related to children (Junco, 2012; Wilcockson, Ellis & Shaw, 2018).

The following table shows the number of studies that used self-reported data and usage data or combination of both. It is evident that the majority of studies exploring technology use by children and university students uses self-reported tools for their data collection. The only two studies that have used a combination of both self-reported and usage data were conducted by Junco (2013) and Wilcockson, Ellis, and Shaw (2018) and they were related to smartphones and Facebook use by adults and students of college. There is no previous research that has explored the concept of Digital Natives and Immigrants and children's digital experiences with the combination of usage and self-reported data and this is something that is illustrated in the table below.

Table 1. Self-report and Usage Data

Paper	Self-reported data (SR)	Usage data (AD)	Combination of both (SR+AD)
Akcayır, Dündar & Akcayır (2016)	✓		
Bhroin & Rehder (2018)	✓		
Brown & Czerniewicz (2010)	✓		
Bullen et al. (2008)	✓		
Hargittai (2010)	✓		
Helsper & Eynon (2010)	✓		
Jones & Cross (2009)	✓		
Jones & Hosein (2010)	✓		

Jones, Ramanau, Cross, & Healing (2010)	✓		
Junco (2013)			✓
Kirkwood & Price (2005)	✓		
Livingstone, Haddon, Görzig, & Olafsson (2011)	✓		
Livingstone, Haddon, Vincent, Mascheroni, & Ólafsson (2014)	✓		
Margaryan, Littlejohn & Vojt (2011)	✓		
Ramanau, Hosein & Jones (2010)	✓		
Selwyn (2008)	✓		
Selwyn (2009)	✓		
Stahl (2017)	✓		
Thompson (2013)	✓		
Wilcockson, Ellis, & Shaw (2018)			✓
Yong and Gates (2014)	✓		
Yong, Gates & Harrison (2016)	✓		

For the third study of the thesis the researcher established a collaboration with Mathletics, one of the most commonly used Online Maths Websites in primary schools, which offered access to children's usage data. The third study combined the collection of both self-reported and usage data. The self-reported data were gathered through the same questionnaire used in study 2 measuring children's digital experience and OMW use, while the usage data were collected from the archive of Mathletics. The only differences between the questionnaires of study 2 and 3 were that in study 3 some of the questions were more focused on the use of Mathletics and included aspects of the OMW use that could be crosschecked by the usage data.

Study 4 had the same aim as studies 2 and 3, but it explored digital experiences and OMW use from the teachers' point of view. Teachers play a crucial role in the ways that technology is used in the classroom by the children and they are the ones who set assessment tasks to their pupils and prepare them for the final year summative tests, so it was of essence to include them in the thesis. The investigation of the teachers' digital experiences was particularly interesting and important, as both theoretical frameworks that are explored in this thesis; Digital Native and Immigrants and the alternative model, which includes Vygotsky, discuss the role of teachers in relation to pupils' technology use and learning respectively. Thus, the fourth and final study of this thesis was designed to investigate teachers' digital experiences and use of OMWs in the same way as with the children. For issues of coherence, the researcher developed a questionnaire measuring teachers' use of technologies at home and the different ways they use OMWs with their pupils following the same format of the questionnaire that was used in studies 2 and 3.

It is worth mentioning that apart from the first study of the thesis, which was exploratory and its analysis was based on thematic analysis, the rest 3 studies of the thesis, which formed specific hypotheses, were analysed through correlations. All the assumptions presented in the result sections of studies 2, 3 and 4 are based on correlations and do not imply any causal relationships between the measures used in the studies. The correlations that were found in the result sections imply that two or more variables are only related and not caused by one or the other. Therefore, the relationships between the variables could go both ways. In addition to that, the strength of the correlations found in the results varied widely, with the majority of the relationships being weak or medium, so the results should be interpreted in this context, with caution and in relation to the theoretical frameworks used in the thesis.

2. Theoretical Frameworks

2.1 Introduction

Information and communications technology (ICT) has become one of the most important parts of everyday life. However, even if technology is quite prevalent in many different settings of someone's life; home, work, school, public transport, there are still people who do not have access to either digital devices, or the Internet. Digital devices include any electronic device that is able to receive, store, process or send any kind of digital information. The gap between those who have access to ICT and those who do not, has become known as the *Digital Divide* (Swain & Pearson, 2001; Kalyanpur & Krimani, 2005; Carvin, 2000; Blau, 2002).

As far as education is concerned, two main concepts have emerged concerning the digital divide. The first is about how the divide is influencing education and the second is the concept that distinguishes students who were born after 1980s, called *Digital Natives* (Prensky, 2001), or *Net Generation* (Tapscott, 1998) as highly technological skilful individuals and the rest who were born before 1980, who are defined as the *Digital Immigrants* (Prensky, 2001). This chapter discusses the two main theoretical frameworks of this thesis; the Educational Digital Divide by Hohlfeld et al. (2008) and the concept of Digital Natives and Immigrants by Prensky (2001). Both concepts have been the focus of much discussion and debate in academia and schools.

The current chapter explains the model of the educational digital divide and then it examines the concept of Digital Natives and Immigrants in terms of how the concept first emerged, who are the empowered and disempowered digital natives, the deterministic nature of this concept, the arguments on both sides of the debate; proponents and opponents, recent developments of similar concepts, the research that has been carried out on the topic over the last few years and up to March 2019, the implications for policy and government, why concepts like these still exist and potential ways forward.

2.2 Educational Digital Divide

Superficially, the digital divide defines the access to technology as a binary situation, where people either do have, or do not have access to digital devices and the Internet, however, the concept is more complex (Harris, 2015). Especially when this divide is related to education, students and learning the complexity of the concept is increasing. Hohlfeld, Ritzhaupt, Barron and Kemper (2008) created a model that illustrates the educational digital divide as a pyramid with three different levels of access, classroom use and student empowerment (see Figure 1).

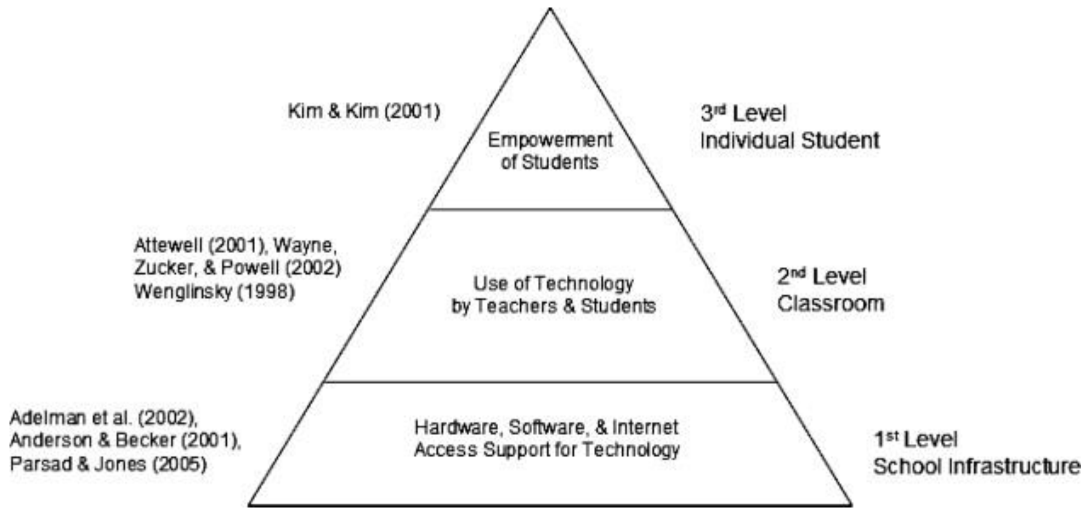

Figure 1 Model of the Educational Digital Divide by Hohlfeld et al. (2008)

According to this model, the divide, starts from disproportionate access to technology, like Hardware, Software and the Internet by schools. However, even if the school does have access to ICT, the divide is not closed, because the kind of use of the technologies is at the second level of the model. Different teachers and different students use ICT in different ways in the classroom and that results in a divide between those who use it more advantageously and those who use it less advantageously. For example, there are situations where the teacher is not familiar with specific kind of technologies, like an interactive whiteboard, and uses it in the same way that he/she would use the blackboard. Thus, the use of the technologies plays an important role in the educational digital divide. The third and last level of the model concerns empowerment of the students, which derives from the combination of having access to ICT and the opportunities for good use of educational technologies. Kim and Kim (2001) described the empowered students as those who "*know how to use ICT for the betterment of the quality of life*" (p.85). In other words, in order for this gap to close, students should acquire the appropriate knowledge and skills to use technologies efficiently.

Thus, from the model the Educational Digital Divide starts across the school, it moves into the classroom and ends up with the students themselves and what they have acquired from their interaction with the technologies. In order to move from one level to another, there should be fulfilment of the requirements of the level above. For example, in order for the students to acquire the appropriate ICT skills, it should be ensured that the school has access to technologies and the Internet and the use of those tools is required for the development of practical and useful ICT skills.

Harris (2015) argued that there are many factors that influence the first level of the educational divide; like ethnicity, race, language, age, gender, but the most important of all is the socioeconomic status (SES) of a person, or a social group in general. Most times, low SES students are in low SES schools, which cannot afford to buy expensive technologies needed to equip the school and so, they are not as advantaged as the high SES students. However, research shows that due to funding programmes and lower cost of technologies, this gap is starting to shrink (Hohlfeld et al., 2008; Warschauer et al., 2004) and the interest is moving from access to technologies to use of technologies in schools.

The ways technologies are used in classrooms determines whether the integration of the technologies leads to the third level or not. The successful implementation of a technological device, or software in teaching is quite complex and requires a very well organised plan and high levels of flexibility from the teacher. Thus, the second level of the educational divide includes measurements of how often technology is used by teachers and students, the reason why it is used and the degree to which those activities are part of the everyday teaching activities (Hohlfeld et al., 2008; Harris, 2015).

If technologies are used in the right way, then they will empower the students with the skills they need in order to use ICT to improve their life. In order to do that, students should be able to take decisions independently and use their technological skills to select the most suitable way of using ICT to accomplish their targets in the most efficient ways

(Hohlfeld et al., 2008). The skills that are deemed to be the most useful due to proper use of technologies are critical abilities, such as academic content knowledge, depth of understanding and problem solving skills (Harris, 2015; DiBello, 2005). These skills are key 21st century skills. However, the third level is the most difficult to reach and it requires the best attainment of both previous levels.

Due to the fact that the specific model for the educational digital divide is quite new, there are no critiques of it. The model explains the educational aspect of the digital divide in a simple and understandable way in terms of technologies in schools, but it lacks the attitudes and previous digital experiences of students and teachers that influence the educational divide. More specifically, it could be argued that there are students who are technologically empowered due to the use of technologies they access at home, without going through the first and second level of the model. Based on that, an important factor that influences the educational digital divide is the aspect of home and the parents. For example, Hargittai (2010) argues that higher levels of parental education are associated with higher levels of students' technological skills, and Stephen, Stevenson and Adey (2013) suggested that the family context makes a big difference to children's engagement with technology. They argued that if someone wants to understand a child's technology use, they should firstly explore the child's family context. The importance of home influences as well as classroom influences is an aspect that has not been explored in frameworks related to children's technology use in much depth. In addition, the second level, which regards the use of technologies in the classroom, does not take into consideration the familiarity that teachers have with technologies and influence to a great extent the way they use them in the classroom (Bevan, 2011).

The educational digital divide in the UK is an issue that is usually overlooked by researchers in education, as the pressure to move on and adapt to the requirements of the 21st century is quite intense and imperative. However, this could be also explained by the fact that according to Liabo, Simon and Nutt (2013), there is no strong evidence of a digital divide in the UK and there is no issue of lack of access to ICT for school students. Nevertheless, they highlight that, even if ICT is accessible in the UK, often it is not used in an efficient way (ibid). Fairlee and Robinson (2013) found that there is no positive or negative effect on the students' school performance of the free provision of computer home access. Thus, as is also evident in the model by Hohlfeld et al. (2008), the importance of the digital divide is shifted from the access to the use and the skills that the students have in order to be able to use ICT effectively.

This shift away from access to use, takes into account factors such as attitudes, skills and support in order to explain the ways students use technologies (Eynon, 2009). This new way of exploring the digital divide from access to use, is also called the "*second-level digital divide*" (Hargittai, 2002, p. 470). Liabo, Simon and Nutt (2013) argued that further research is needed to determine the different ways in which patterns of access and use of ICT influence educational performance. Especially in terms of children's access and use of ICT, there is a lack of research, because children and young people are perceived to be ICT experts regarding new technologies (Livingstone & Helsper, 2007). A perception that originated by Prensky's (2001) and his differentiation between Digital Natives and immigrants.

2.3 Children living in a digital world

The idea that the children who have grown up in a world immersed with technologies are different than all the previous generations started more than twenty years ago. Theorists and educationists such as Tapscott (1999, 2009), Howe and Strauss (1991, 2000), Prensky (2001, 2009, 2010), Oblinger and Oblinger (2005), Palfrey and Gasser (2008) and others believed that the interaction that children have with technologies makes them think and learn qualitatively differently to everyone else who were not raised surrounded by technologies. They argue that because of this difference in thinking and learning students require new and innovative ways of teaching and learning with the use of new digital technologies.

2.3.1 How everything started

Tapscott (1999) was the first person who talked about a generation of children who learn and think differently than their previous generations due to their access to digital media. He called this generation of people the *Net Generation* and defined them as being born between 1977 and 1997. Howe and Strauss (2000) coined the term *Millennials* and they were people who were born between 1982 and 2004. They also argued that these people are distinctive and different from all previous generations due to their interaction with technologies and good education. The third person who based his concept on the Net Generation and the Millennials was Prensky (2001). He named the people who were born and raised with technology as *Digital Natives*, but he also went a step further to name those who were born before that as *Digital Immigrants*. Prensky (2001) based those names on the fact that Digital Natives know how to use and interact with technology, as they were raised with it, while Digital Immigrants need to learn how to do that at a later stage of their lives. He did not set a specific start and cut-off point for these generations, but referred to them as the students who were then at K-12 stage and through college, which makes them born after 1980.

These terms became quite popular when Oblinger, Oblinger and Lippincott (2005) published their book on *"Educating the Net Generation",* which was also the time that educators and academics started to think how the use of technology and the technological skills have influenced education, teaching and learning (Judd, 2018). All three concepts and terms argue that there is a homogenous generation of people who think, behave and learn differently from other generations due to their digital experiences. However, the concept of Digital Natives and Immigrants by Prensky (2001) is the one that has been mentioned and cited in academic, learning and teaching sources the most from 2008 until 2014 (Judd, 2018) and it is the one that the thesis is examining in more detail as it is the only one that distinguishes between digital natives and digital immigrants; the two groups examined in the thesis. The specific framework was chosen also based on the fact that the teachers who took part in the first exploratory study of the thesis referred to technology use as a generational issue. In addition to that, this framework, although it has been criticised heavily the last few years, it is still used in recent educational blogs that support the idea that digital natives exist and teachers and educators need to rethink education for their students (Adobe Communications team, 2018).

On the other hand, a very recent study which explored teacher candidates' beliefs and pre-schoolers' actual skills with digital technology and media found that the children could complete 9 out of 12 iPad tasks without any help, while the teachers thought that the children would need assistance more often than that (Mourlam, Strouse, Newland & Lin, 2019). The fact that the teachers underestimated the pupils' technological skills could be linked to the criticisms that models like digital natives have received the last few years and reservations in relation to children's technological skills. This shows that teachers need to guess their pupils' technological skills and the evidence suggests that the assumptions they make are not as accurate. Thus, the use of Prensky's (2001) framework in the thesis is a way to stress to teachers and educators that any assumptions, either these are believing that children are experts in the use of technologies or they need more help that they actually do, are not correct. Teachers should find a way to capture their pupil's technological skills at the beginning of the school year without having to guess. A way that this can happen in schools is discussed in the last chapter of this thesis.

The current section is going to focus mainly on the concept of Digital Natives and Immigrants, Millennials and Net Generation, as those are the terms that are strongly related to education. However, it is also worth mentioning that there is an extensive number of similar terms that describe a generation of people who are more technologically savvy than others. Apart from the Net Generation (Tapscott, 1998; Oblinger & Oblinger, 2005), Millenials (Howe & Strauss, 2003) and Digital Natives/Immigrants (Prensky, 2001; Palfrey & Gasser, 2008) similar terms include Generation Y (Jorgensen, 2003), IM Generation (Lenhart, Rainie & Lewis, 2001) referring to Instant Messages young people send, the Gamer Generation (Carstens & Beck, 2004), Homo Zappiens (Veen, 2003), Google Generation (Rowlands et al., 2008), i-Generation (Rosen, 2010). All the terms are quite similar with minor differences. However, the fact that they do not all agree on a specific common year that this new generation of tech savvy people were born and, they cannot all decide on which term is the best to describe this generational shift shows the difficulty and ill-defined nature of research in this area.

2.3.2 Digital Natives and Digital Immigrants by Prensky

Prensky (2001) started his paper arguing that the reason behind the decline of education in the US is the fact that students have changed dramatically the last few years due to their interaction with technologies. He even suggested that the change that happened was so extreme, that he described it as a "*discontinuity*" and "*singularity*" (p.1) that took place due to the introduction of technology in children's lives. He decided to call them Digital Natives, as they were all native speakers of the same digital language. Then, he continued to name the rest of the people born before 1980 as Digital Immigrants, because they were the ones who were not born in a world surrounded by technology and they would have to learn how to use it at a later stage of their lives. He claimed that no matter how much digital immigrants try to learn how to use technology, they will never reach the same level as digital natives and they would always keep their *immigrant accent*.

According to Prensky (2001), Digital Natives are people who can process information fast, they are experts in multi-tasking and parallel processing, they like being online, they prefer random access to information using hypertext, graphics and images than text, and gaming than work. He argued that the differences between those two groups of people; the natives and the immigrants, are obvious and they have a great influence on the way students live nowadays. However, this separation of people into two groups based on the year they were born and their exposure to technology has raised a great debate in relation to whether a distinction like this is working in favour, or against the interest of the students.

Proponents of the concept argue that students have changed radically over the last years and they represent a new generation that has grown up with technology and requires a transformation of teaching and learning (Prensky, 2001, 2010; Tapscott, 1998, 2009; Green & Hannon, 2007; Thomas, 2011). The main argument for this concept is that the use of technologies has physically changed students' brains and as a result, they think and process information in an essentially different way from the old students. According to Prensky (2001), today's learners, or so called Digital Natives, are able to receive information quite fast and are skilled in multi-tasking and digital graphics, instead of plain text, demanding a different kind of education in terms of methodology and content. According to Thomas (2011) and based on what Prensky (2001) and Tapscott (1998, 2009) have discussed, the main argument of this framework is that young people born after 1980s are all part of a homogenous generation which speaks a different language than the digital immigrants, the language of digital technologies. This generation learns differently from the previous generations and requires an innovative way of teaching and learning which should include the use of technology.

2.3.3 The empowered digital native

Digital Natives as described by Prensky (2001) and the other authors in this area constitute a unique generation of people who are empowered due to their interaction with technology. The term of digital natives is usually linked to positive attributes, such as the fact they have advanced knowledge of how technology works. Selwyn (2009) wrote about the empowered digital native explaining how technology has made young people's life easier, by giving them the choices of how and when to interact with others. The Internet is considered to be one of the most powerful tools that allows people to manage and organise their activities and widen their horizons gaining information from many different sources.

A strong example of this is the use of technologies and the Internet in education. Students can use the Internet in order to gain access to information and knowledge that they would not be able to without the assistance of technology. They have the opportunity to use technologies in order to transform their learning experiences and from passive consumers of learning material to become active learners. The power of the Internet allows them to create content together with other people from around the world, but also criticise, challenge and question views of others. In that way they can become more sceptical creators of content. Technology offers digital natives the chance to develop all these technological and intellectual skills in order to improve the quality of their lives.

2.3.4 The disempowered digital native

However, even if being a digital native is usually seen as a positive aspect and one that empowers the person who is characterized by it, there are also authors who are concerned about the interaction of young people with technology (Selwyn, 2009; Byron Review, 2008; Keen, 2007; Fearn, 2008; Brabazon, 2007). They argue that the use of technology sometimes includes risks and dangers that can actually disempower the user rather than empower them. The main risk they express is related to potential exposure to inappropriate content on the Internet, such as physical and emotional risks that put young people in danger of harming themselves as well as others. However, the risks are not only related to the personal nature of the user, but also their education and learning. Concerns have been raised regarding whether the use of technologies and the Internet has made young people more keen on plagiarism and less capable of being critical. Brabazon (2007) argued that the large amount of online resources available on the Internet puts inexperienced students at risk of making bad personal decisions and getting lost instead of asking the teacher for help. The idea that young people have all the knowledge they need is only a click away and everything they have to know is somewhere on Google is a risk that can potentially lead them to poor judgements and insufficient rushed school and later academic work.

Furthermore, Keen (2007) and Bugeja (2006) suggest that the interaction with technology has also made significant changes to some young people's behaviour. It is noted that young people today pay more attention, effort and time using their digital devices for purposes of self-expression, self-promotion and self-broadcasting, while they are less inclined to listen and learn from others. The excessive use of social networking sites amongst young people has created a culture of digital narcissism (Keen, 2007) that promotes self-centred behaviours. Best, Manktelow and Taylor (2014) stressed that excessive use of online technologies and social media can lead to harmful effects on children's wellbeing including social isolation, depression and cyber-bullying. While the proponents of the digital natives concept embrace all changes the interaction with technology brings to young people, others approach these concepts with more caution and take into consideration the dangers of immersion in a world of technology.

2.3.5 The deterministic nature of the digital natives discourse

Jones (2011, 2012), Jones and Shao (2011), Selwyn (2003) and Sorrentino (2018) have discussed the deterministic nature of the digital natives discourse and the similar concepts such as Net Generation and Millennials. They argued that all these concepts have something in common. They explain the link between technologies and change as something that just happened in people's life, independently from everything else and it has an impact on different domains of society and more specifically, inevitable consequences for learning. Their deterministic nature is clearly illustrated by the fact that young people have no choice but be part of the Digital Natives who are experts in the use of technologies and the older generations have no choice but to be part of the Digital Immigrants who, not matter how hard they try, they will never be able to reach the technological skill of Digital Natives. The generational clash that these concepts support is a force for change; and all changes that come from that clash are inevitable. Most importantly, the changes these concepts discuss are related to education, teaching and learning and the dynamics between the teachers and the students. However, this deterministic approach of these concepts fundamentally fails to reflect the diversity and complexity found in real lives of real people.

2.3.6 Implications for education based on proponents of Digital Natives and Immigrants

The implications that concepts like Digital Natives and Immigrants have for education are used as the authors' main argument for quick and important changes in teaching. As mentioned above, Prensky (2001) has argued that Digital Native students have different structure of brains due to their extensive interaction with technologies and that makes them think and behave differently than previous generations. In addition to that, their differences include the fact that they can receive information very fast, they are keen on multi-tasking and parallel processing, they prefer graphics than text, they like to be online, they prosper when they receive instant feedback and they enjoy gaming more than working.

Thus, based on these changes, Prensky (2001) stated that *"..the single biggest problem facing Education today is that our Digital Immigrant instructors, who speak an outdated language (that of the pre-digital age), are struggling to teach a population that speaks an entirely new language*" (p.2). He argued that Digital Immigrant teachers do not understand or appreciate all the new skills that their Digital Immigrants students have acquired through their interaction with technology and they prefer to continue using their old and tested teaching methods. However, he believed that those methods do not work for Digital Native students anymore and the changes in the educational system should include both the methodology of teaching and its content.

According to Prensky (2001), the methodology of teaching should be updated in order to meet the new ways of learning of the Digital Natives by introducing a faster, more parallel style of teaching which will use their own digital language. The way he suggests teaching will become very successful is with the use of gaming. If all teachers can use gaming in order to teach their subjects; from maths to history, then all students will be interested in it and will be able to understand more than if everything was only included in a textbook. Regarding the content of the subjects, Prensky (2001) believed that the traditional subjects of the curriculum; maths, reading and writing should remain the same, but there is also new content that should be introduced into classrooms. The new subjects should include digital and technological content; hardware, software and robotics. However, he stressed that even if those changes happen in order for the educational system to become more successful, the Digital Immigrant teachers will not be able to teach these subjects.

As Jones and Shao (2011) noted in their article, Prensky's argument about education has two aspects that do not seem to be valid. Firstly, he argued that the education system should change its teaching methods and taught subjects in order to meet the Digital Native students' needs, but even if that happens the Digital Immigrant teachers will not be able to teach these appropriately. And even if they do try to learn the students' digital language and attempt to teach in the style the students need, they will still not be able to reach the level of their students and they will always retain their "*accent*" as Digital Immigrants. Thus, the specific argument does not seem to offer a possible solution to the educational problem, as described by Prensky (2001) himself. The second problem with this argument is that it takes as a given the fact that all students today are Digital Natives. They are skilful experts in the use of technology but unfortunately Prensky only provides anecdotal evidence to support that claim. Thus, it can be considered only an assumption and not a valid argument.

A similar argument was also made by Tapscott (1999) who approached the same issue from a slightly different angle. Tapscott (1999) agreed with the fact that teachers need to learn new skills and methods of teaching, but in his argument he made the students the centre and leading the changes. He argued for a more student-centred way of teaching rather than teacher-centred, where the students will be the ones who will introduce new ways of using technology in the classrooms. A more student-centred style of teaching was not a new suggestion as at that time other people were also making this suggestion.

According to Jones and Shao (2011), there were more authors who believed that the education system needed changes in order to meet the students' requirement and needs. Dede (2005a, 2005b) and Palfrey and Gasser (2008) believed in the concept that technology had changed the way students were thinking and that teachers had to adjust their techniques to the ways young people learn; the "neomillennial" ways of learning as Dede named it. However, Palfrey and Gasser (2008) admitted that these kind of changes are quite complicated and the educational community is quite confused by how to proceed with those changes. It is evident that all the above authors are strong believers of the fact that the students today acquire the characteristics of Digital Natives and the educational system has to change in order to meet their new technological ways of thinking and learning.

2.3.7 Recent developments

Digital Wisdom

Prensky (2009) has now developed the concept of *Digital Wisdom*. The basis of this idea is that one day, really soon, even the less developed countries will have access to digital technologies and there will be no divide or separation between those who have and have not access to technology. The term *Digital Wisdom* is used to describe the fact that digital technology can make people not just smarter, but wiser. This wisdom is originated from the use of technology, as the brain is deemed to be highly plastic and thus, it changes according to the input it receives. He also supports that digital tools have the ability to extend and enhance the cognitive abilities of a person in many different ways. By cognitive abilities, he refers to memory, judgement and critical thinking. It is worth noting that the main change between his concept with Digital Natives and Immigrants and Digital Wisdom is that now everyone is moving towards digital enhancement, even the Digital Immigrants.

He attempts to rename the digitally enhanced person from Digital Native to *Homo sapiens digital or digital human* (p.2). *"Homo sapiens digital, then, differs from today's human in two key aspects: He or she accepts digital enhancement as an integral fact of human existence, and he or she is digitally wise, both in the considered way he or she accesses the power of digital enhancements to complement innate abilities and in the way in which he or she uses enhancements to facilitate wiser decision making. Digital wisdom transcends the generational divide defined by the immigrant/native distinction. Many digital immigrants exhibit digital wisdom*" (Prensky, 2009, p.2). The Digital Wisdom approach is not very different from the original concept, it remains deterministic in its nature, but it reduces the divide and distinction between Natives and Immigrants. Thus, it could be argued that it moves from a more hard determinism to a softer version of it (Jones, 2011).

Born digital

Another development in relation to the concept of Digital Natives and Immigrants was made by Palfrey and Gasser (2008) in their book named Born Digital. Their aim was to understand the first generation of digital natives and reclaim the term Digital Natives. They believed that the specific term could be useful in an academic context if it was slightly changed. They argued that the problematic aspect of the Digital Native concept was that it referred to a whole generation, while they suggested it should be a term for a population rather than generation. The Digital Native population according to Palfrey and Gasser (2008) is defined by its access to technology and not a cutting point based on a birth year. They also argue that the access to technology is not considered given and it is linked to a person's digital literacy. However, their attempt to reclaim the Digital Native term did not address all the problematic issues that the concept had, as having a smaller group of people dependent on access to technology and digital literacy is not far from the original concept developed by Prensky (2001).

Digital melting pot

Stoerger (2009) proposed another metaphor called the *Digital melting pot* as a response to Prensky's (2001) dichotomy of Digital Natives and Immigrants. His aim was to move the interest from the common characteristics and skills of a generation to the ones that each individual is acquiring through their interaction with technology. He tried to bridge the gap between the Digital Natives and Immigrants by suggesting that whoever gains experience using digital devices and technology in general can acquire technological skills. Thus, in terms of education, if the teachers had enough digital experiences themselves, then they would be able to assist their students to acquire, improve and develop their own technological skills.

Digital visitors and residents

White and Le Cornu (2011) introduced the continuum of "*visitors and residents*" as a replacement for Prensky's (2001) Digital Natives and Immigrants concept. Their terms aimed to describe a person's engagement with the Web and they argued that the metaphors "*place*" and "*tool*" are the most accurate to describe today's use of technology, especially if the factor of social media is taken into account. These terms create an experiential divide (Jones & Shao, 2011) which differentiates people dependent on their online use of technology based on their motivation and context. According to White and Le Cornu (2011), a resident spends a considerable amount of their time online and they have a digital identity via their social networking profile/s, while a visitor uses the Web as a tool only to meet their specific needs and achieve their goals. The age or the background of the user do not play any role in how people use the Web.

2.3.8 The debate/criticism

This section is going to discuss the debate of the concept of Digital Natives and Immigrants along with the other similar frameworks of Net Generation and Millennials. It presents the critique that Digital Natives have received, what the empirical research says and what previous reviews have found from 2001 when the concept was firstly introduced up to 2019, 18 years later.

The general idea which supports a generation of people who are experts in the use of whether technologies because they grow up in a digital world is the same regardless of what it is called; Digital Natives, Net Generation or Millennials. There are many authors who believe in this idea, but there are also some who have started to question the idea that someone can acquire high technological skills based on their birth year. The opponents of the concept argue that the problem with this idea is that it fails to acknowledge and account for the diversity and complexity that characterises real life (Helsper, 2008; Jones, 2011; Sorrentino, 2018), and its deterministic nature presents Digital Natives and Immigrants as two groups of people who share only differences and they cannot understand each other.

This idea has faced strong criticism and has been characterised as a form of *moral panic* (Bennett, Maton & Kevin, 2008; Cohen, 1972). By moral panic, Bennett and Maton (2011) mean "*a form of public discourse that arises when a group is portrayed as representing a challenge to accepted norms and values in a society"* (p.173). In other words, it is a rapid reaction to the fact that a big change is happening and people have to adjust to this new reality. The main arguments against these terms are the lack of empirical basis, they are undertheorised and supported by anecdotes and appeals to common-sense beliefs and not real evidence based on research. The statements regarding digital natives seem really strong, but there is no actual evidence behind them and no theoretical framework to explain how this generation of people developed the same high level technological skills (Jones, 2011). The main evidence that Prensky (2001) used to build his framework were his own observations of his children and students at the schools he visits. However, there is enough evidence from empirical studies across the world which proves that there is a great variation of technological skills, interests, motives and behaviours amongst today's students. They do not all belong in one homogenous group in terms of their technological literacy.

Jones and Shao (2011) reported empirical evidence from countries across the world; including the United Kingdom, European countries like France, Germany, Spain, Austria, Netherlands, Norway and Denmark, North America, South America, Australia, Canada and China, in relation to claims of the Net Generation and Digital Natives and Immigrants in higher education and they concluded that there was no universal generational change in attitudes and skills of students as a result of their interaction with technology. The students' experiences were far from universal and the ways they use technologies vary to a great extent, especially when they move beyond the basic functions and technologies (Jones, Ramanau, Cross & Healing, 2010; Kennedy et al., 2008). Even if students have access to a variety of different technologies and learning tools, evidence suggests that students use technologies mainly for social and entertainment reasons rather than learning. In addition to this, research showed that although students might use technologies a lot, when it comes to their learning they prefer a moderate use of ICT. They are using online learning tools when they have to, but they are not great users of Web 2.0. Being a great user of Web 2.0 requires people to contribute to the content of the Internet as much as they consume it (Andersen, 2007).

One of the most important points that Jones and Shao (2011) made in their article is the fact that the Digital Natives and Immigrant concept describes a number of divides. Firstly, a generational divide amongst Natives and Immigrants based on their year of birth and their technological skills. Secondly, a divide between teachers and students who speak different languages and regardless of how hard the teachers try to learn the digital language of the students they are never going to succeed. However, the empirical evidence showed clearly that the generational divide does not exist and the divide between the teachers and students has been exaggerated. They conclude that what is needed is new and innovative methods of collecting data about the daily activities of students in order to get a better understanding of the relationships between the students and their digital experiences.

Kirkwood (2006, 2008) and Kirkwood and Price (2005) conducted research on the interplay between new technologies at university and pedagogical approaches. They suggested that even if ICT could offer innovative ways of teaching and learning, it was really important that any changes and reforms happened after careful consideration of educational purposes and pedagogies (Kirkwood & Price, 2005). Kirkwood (2006, 2008) reported that although a considerable amount of the students who took part in his research had access to different kind of technologies and their skills were above the basic level, only some of them acquired information literacy skills. He was one of the first authors in the area who stressed the fact that there was a danger of the teachers taking students' technological skills as a given, which would be more harmful for them rather than helpful.

Selwyn (2008) conducted research to explore how undergraduate students use the Internet for academic purposes. The results of 1222 students showed that the way they were using the Internet for learning purposes was strongly related to gender and discipline differences instead of access and technological skills. Students were using the Internet to search for information related to their studies, but this was not the main or most common reason for them to go online. In 2009, Selwyn focused his research on the use of Facebook as part of students' role at university and he found that Facebook and social networking sites had become an important part of being a student and they were using them to a great extent, even more than they were using the Internet for their academic studies.

Helsper and Eynon (2010) used the data of the Oxford Internet Survey of 2007 (OxIS), a national British survey, carried out by the Oxford Internet Institute (University of Oxford) in order to determine whether the nature of a digital native is based on their age, experience of Internet use and breadth of use on the Internet. They argued that although some of Prensky's (2001) arguments regarding digital natives were supported by their findings; such as increasing numbers of young people who were using the Internet, they were coming from a media-rich household, they were more confident about their technological skills and they were also more likely to be involved in online learning activities, that does not make a distinct generation. Some of the factors that explained the ways the young people were using technologies more were their gender, education, experience and breadth of use with the breadth of activities that they do online being the most essential factor to define if someone could be considered as digital native. They argued that the connection between technology use and brain structure of children is still under investigation. However, the fact that they found similarities as well as differences between the different generations of people can confirm that the use of the Internet amongst people lies along a continuum and not a schism.

The Economic and Social Research Council (ESRC) launched the *Net Generation encountering e-learning at university* project from January 2008 until March 2010 which aimed to explore the use of technologies and the Internet by first year university students. The project included five universities in the UK and fourteen different courses. Jones, Ramanau, Cross, and Healing (2010) conducted research on the first phase of the project and found that the first year students, although born after 1980, did not constitute a homogenous generation of ICT skilful young people. The sample included many minorities of students with smaller groups of students not using technologies to a great extent and some larger groups of students using technologies extensively. It seemed that the students were spending a lot of time on computers and the Internet but they were not using blogs, wikis and virtual worlds as much (Jones & Cross, 2009).

Jones and Hosein (2010) found there is no single generation of digital natives. They argued that the age factor is only just one amongst many other interrelated factors; such as gender, national origin and mode of study, that influence how students use technologies. Further studies also suggest that factors such as the socio-economic profile of the students is more important rather than the age. Brown and Czerniewicz (2010) argued that the digital native characteristics are those of a '*digital elite'* (p.357), as the students who are wealthier have more chances to have higher levels of technological skills. Hargittai (2010) supported the same argument and suggested that race and gender were two of the most important factors together with the socioeconomic status of someone which could determine high technological skills. As part of the second phase of the project Ramanau, Hosein and Jones (2010) found that the Net Generation students were spending more hours using their digital devices to socialise (approximately 2.2 hours per day), while the older, non-Net Generation students were spending more time on their technologies for studying purposes (approximately 1.7 hours per day).

Margaryan, Littlejohn and Vojt (2011) conducted research on the use of technology amongst university students in relation to socialisation and learning. They found that students only use a short number of already established technologies, such as mobile phones, media players, Google and Wikipedia. The digital native students and more specifically those who were studying engineering use more digital tools than the digital immigrant students who were coming from social sciences. However, they stressed that the differences found between digital natives and immigrants were mainly focused on the quantity of technological use rather than the quality. Their research did not find any evidence that would support the concept of digital natives and immigrants, as the results showed that the two groups did not have fundamentally different ways of learning. Their use of technology was mainly influenced by the teaching style of their lecturers and students seemed to comply with the traditional pedagogies and moderate use of digital learning tools.

Bullen et al. (2008) also suggested that students do not seem to realise how powerful and helpful the technologies they own could actually be for their learning, as they are mainly passive users of the online learning tools they have access to, for example they tend to use technology to download teaching material like lecture notes and find information on Wikipedia. Margaryan, Littlejohn and Vojt (2011) highlighted that technologies should not be implanted in education just for the sake of it, but the decisions made for the implementation of digital tools in teaching and learning should be based on the educational value they are going to offer to both teachers/lecturers and students.

2.3.9 Most recent empirical research on Digital Natives

Thompson (2013) conducted research in the US to explore whether the claims for digital native learners were confirmed by empirical evidence. The research included 338 first year students of a large Midwestern university who completed a survey and answered questions regarding whether they thought the claims made by the concept of digital natives matched their own approaches to learning, and if their approaches were successful in terms of focused attention, deep processing, and persistence. The findings suggest that students do not use as many digital tools as Prensky (2001) argues and they do not seem to take full advantage of all the possible benefits those tools can offer them in relation to their learning. The ways that technology influences students' approaches to learning vary widely, they are complex and do not follow the deterministic nature of the digital natives concept. However, one of the most important arguments Thompson put forward is that even if the students have some of the digital native characteristics, they cannot be fully independent learners without the help and guidance of their teachers. She actually highlighted that the teachers' role is very critical in teaching students how to use technology in the best possible and most effective ways for their learning.

Thompson's follow up study in 2015 investigated how digital native learners actually describe themselves in relation to the characteristics Prensky (2001) ascribes to them. Although this was an exploratory and small in sample study, it showed that students agreed with some of the claims, but they also reported that they needed to develop strategies in order to manage the distractions technology was creating for them and stopping them from pursuing their educational goals. This is an important finding and it adds to the above mentioned disempowered digital native (Selwyn, 2009).

Akcayır, Dündar and Akcayır (2016) explored what makes an individual a digital native and whether it is enough to be born after 1980. They used the Digital Native Assessment Scale (DNAS) developed by Teo (2013) and recruited 560 university students. They concluded that the year of birth is not a determining factor to make someone a digital native. The factors that actually seemed to affect students' relationship with technology were their education, culture and technology experience. However, it is worth mentioning that when Yong and Gates (2014) and Yong, Gates and Harrison (2016) used the same scale, DNAS, for their research, they found that pre-university students in Malaysia did actually meet the criteria to be called digital natives because they were born after 1980 and they were doing all the activities a digital native is supposed to do according to Prensky (2001). More specifically, they found that all students were using the Internet extensively, with female students spending more time on using their mobile phones for communicating with friends and listening to music, while male students tended to spend more time on computer games. The difference between the results of these studies raises questions in relation to differences in the use of technologies amongst cultures.

Stahl (2017) carried out research on university students' skills and use of technology in relation to their Digital Native title and found that the results were in agreement with the existing research which argues that there is not a heterogeneous generation of technology savvy people. Due to the fact that the technological skills between the students varied significantly and in some occasions those skills did not even meet the requirements in academic studies. Stahl argued that the second level digital divide, which is when people have access to technology, but they do not have the skills to use technology as efficiently as they could do, is still a problem that universities and education have to face.

Two of the most recent reviews of the literature and the empirical evidence of the Digital Natives debate were written by Kirschner and De Bruyckere (2017) and Sorrentino (2018). Kirschner and De Bruyckere (2017) reviewed a number of international studies that prove the term Digital Natives to be misleading. They found that people who were born after 1984 did not have any high level technological skills, on the contrary, their knowledge and skills were limited to basic office suite skills, emailing, texting, Facebooking and surfing the Internet. The technologies they use for their academic studies and the ways they use those technologies are not as pioneering as Prensky (2001) suggested they would be. Based on their review, students tend to consume the content of the Internet rather than to create it by using wikis and blogs. They focused their review on one of the aspects which is associated with digital natives the most; multi-tasking. They provide evidence to prove that digital natives are not great at multi-tasking and, in fact, multi-tasking has negative consequences for their learning because it impairs their performance.

Sorrentino (2018) in her review aimed to explore whether there is empirical evidence to support the metaphor of digital natives. She also presented extensive research which argued against the existence of a tech-savvy generation of young people. She highlighted that there is no fixed divide between natives and immigrants and it is not one that cannot be bridged. However, she suggested that even if the digital native discourse if not the best one to describe a generation, some of the newer concepts such as the '*digital melting pot*' by Stoerger (2009) and the *'residents and visitors'* (White & Le Cornu, 2011) offer different ways to understand how young people use technology today. A good way forward for a nuanced understanding of how young people use technologies would be to explore more their experiences, breadth of use, gender and social status.

2.3.10 Research on digital natives with young students

It is evident that most of the empirical research in relation to the concept of digital natives is focused on higher education and students at university. The research on younger children is not so extensive.

Livingstone Marsh, Plowman, Ottovordemgentschenfelde, and Fletcher-Watson (2014) did research focused in the UK to investigate how young children aged between 0 and 8 years old use digital technologies. They found that technologies are an important part of young children's lives with the tablet being the digital device most commonly used amongst children. The main activities children engaged with the digital devices were related to entertainment such as playing games. The use of educational applications was not very common, especially for children aged 6 and 7 years old. The educational applications included information gathering, creative production such as drawing, and instructional videos from YouTube. Livingstone, Haddon, Vincent, Mascheroni, and Ólafsson (2014) examined the self-reported competence and confidence of children aged 9-16 years old in the UK and they found that, in contrast to Prensky's (2001) arguments, they do not naturally or automatically acquire high level digital skills.

Livingstone, Haddon, Görzig, and Olafsson (2011) conducted a European study called the "EU Kids Online", which is a multinational research network active in 33 European countries. They surveyed 25,000 children aged 9-16 years old and their parents regarding the children's use of Internet. Based on their results they tried to debunk the most common, biggest myths people believe in relation to children and technology. They placed the term Digital Native as the number 1 myth, as they found that only 1 in 5 children knew how to share a file and create an avatar online, while half that number owned a blog. The main use of the Internet seemed to be just consuming ready-made content, rather than creating their own.

As part of the same EU Kids Online project Bhroin and Rehder (2018) explored how Norwegian children aged between 9-15 years old understand technologies, digital media and the Internet. They conducted qualitative observations and semi-structured interviews with children from three different schools. In terms of the technical expertise of the children the researchers noticed that teachers and adults were referring to the children as digital natives and experts in the use of technologies. It seemed that this was mainly a way for the teachers to motivate and engage the children to learn more on how to use technologies. However, the researchers noticed that the children did not acquire all the technological skills they were thought to have. The researchers pointed out that this situation could be risky and dangerous, because when the children are presented as the experts and they are considered to know more than their teachers and parents, they might not ask for their help and support when they need it. Especially because they might know how to program a game and download new applications, but they are not fully aware of the risks and dangers that accompany their actions online.

The most recent Ofcom report published in January 2019 estimated that the weekly use of the Internet by children aged 5-15 years old has increased approximately 6 hours 18 minutes from 9 hours 18 minutes in 2009 to 15 hours 18 minutes in 2018. It seems that most of these hours, around 11 hours are devoted to gaming. The three main activities they undertake online are related to making drawings, changing and editing photos and making videos. Thus, it is evident that young people’s use of technologies is increasing year by year, however, the understanding of the interplay between how young people use those technologies and how that links to their school performance at the level of primary school is still not investigated.

2.3.11 The power of common sense/ why the millennials and digital natives still exist

Although concepts like the Digital Natives and Immigrants (Prensky, 2001), Net Generation (Tapscott, 1998), Millennials (Howe & Strauss, 2000) have received strong criticisms and there is little research to support their existence, the public and academic interest and use of these terms continues to exist. Judd (2018) conducted a study, which aimed to evaluate the level of interest for these terms by academics and the general public. His study covered an almost 20 year long period of interest; from 1998 to 2017. The data were collected from Google trends, Google's main research tool and Google scholar. On the question if digital natives are still relevant, Judd supports that it is merely down to who is asked and how broad the term is. His results showed that when all three terms; digital natives, millennials and net generation, are taken into account, then the answer is yes for both the public and academia.

The general population seems to be interested in all three terms, but since 2012 the term millennials is the one that has gotten the most searches and attention. Academia seems also interested in all three terms with a moderate increase of articles including at least one of the terms between 2006 and 2016. The interest in millennials is also stronger between academics, while there is a slight decline in interest for digital natives since 2015 and Net generation since 2011. Overall, Judd (2018) believes that millennials gained a growing interest over the last few years because they represent all technological skilled generations and labels of the same concept. The growing interest in these terms is not always related to education, but the connection between the two will always remain strong.

When examining the reasons why these terms are still in use and of interest, one of the mot important ones is that they all appeal to common sense and it is easy for people to believe them and follow them. Jones (2011) and Sorrentino (2018) supported that one of the reasons is a general need to stereotype and group people in order to make it easier to understand them. In addition, frameworks like these seem to be right and are widely accepted by the public, as they are based on common sense and most people have seen children engaging enthusiastically with technology demonstrating some sort of expertise from an unexpectedly young age. However, in most of these occasions children engage with technology for purposes of entertainment and not in an educational context. Another reason is the fact that these terms have been used extensively in marketing to target specific groups of people who are experts in the use of technologies. One of the earliest published articles in the journal of Strategic

Marketing was titled "*Mobile advertising to Digital Natives: preferences on content, style, personalization, and functionality*" (Smith, 2019).

2.3.12 Implications for policy, government and government agencies

Proponents of the Digital Native discourse argue that changes in education are necessary in order for the educational system to meet the requirements of digital native students. Education is urged to make revolutionary changes in its technical infrastructure, professional development systems, pedagogy and curriculum (Jones & Shao, 2011). The terminology used by Digital Natives, Millennials and Net Generation is used widely in public, educational and political debate (Sorrentino, 2018). However, based on the fact that there is limited empirical evidence to support Prensky's ideas, Kennedy et al (2008) argued that educators and policy makers should always inform their decisions based on empirical evidence and not common sense beliefs. Jones and Shao (2011) highlighted that in order to develop policies that are appropriate for the students who were raised with technologies researchers and educators should improve their understanding of the situation and encourage further research that explores the ways students use technologies in terms of factors such as their experiences and breadth of use rather than their birth year. In addition to that, governments should avoid taking claims such as Digital Natives at face value without researching the evidence.

2.3.13 Moving beyond the concept of digital natives

In an educational context, the key factor is how teachers and schools can handle those differences and the diversity within the students and their technological skills. Educators should be aware and take into consideration the different types, attitudes, experiences and opportunities that the students have with technologies, in order to find the right ways of integrating ICT in teaching, learning and assessment. If the diversity of digital experiences between the students is overlooked, it might be more harmful than helpful for some children (Bennett, Maton & Kervin, 2008). In addition, according to Kennedy et al. (2009) and Coombes (2009), the role of education is of primary importance in order for students to become technologically empowered, because some of the young people might have confidence in using technologies, but limited understanding of how technologies work and how they can use them to learn.

Taking into consideration both sides of the debate, the thesis explores the phenomenon through a more nuanced and complex framework, which takes into account teachers' and students' attitudes towards technologies, their digital experiences with different types of digital devices and, how these influence the educational digital divide and the way students use and learn through technologies. As Palfrey and Gasser (2011) argued, it is wrong to divide young and old people by their use of digital technologies, as different people at different ages have adapted technologies in different rates during their lives. There is no such generation of young people that all use technology in exactly the same ways. Instead of that, they claim that there are some young people who use technologies in a more sophisticated way than others do, but not that the whole generation is thinking identically. Herring (2008) made a very important point saying that all these concepts describe young people and their experiences with technologies through the lenses of adults, which may not reflect the young people's own reality of the situation.

It is evident that many authors have attempted to reclaim the terms of Digital Natives and Immigrants, try to bridge the gap between generations or even replace them completely with new terms and concepts that illustrate how people use technologies today. There is a belief that having terms like that will be useful in terms of finding tactics to tackle issues that occur due to the changes that technology brings to young people's lives. However, there are also many authors like Jones (2011), Koutropoulos (2011) and Judd (2018) who suggest that all these terms should be abandoned because they are problematic, misleading and they create more confusion in the educational systems and policy makers than solutions.

There is no doubt that education should not stay the same through the passage of the years and should try to adapt to the social, political, environmental and economic challenges of the 21st century. However, in order for education to change effectively, new phenomena, like the educational digital divide, should first be researched and understood in depth, in order to detect what requires change, what is possible to change and how it can be changed (Maton, 2002).

The research that will address these changes should not focus solely on theories and models that are framed around the use of digital devices, as it has been shown that models like these (e.g. Digital Natives, Millennials and the Net Generation) are not based on research based evidence, but personal observations of the authors. These theories are inadequate of explaining technology use accurately, as they do not take into account the bigger picture of the phenomenon, the social aspects that shape technology use. The criticisms that were discussed above, together with research-based evidence that does not support these frameworks have established that technology use is not innate or determined by someone's birth year, but it is learned. Thus, a better, alternative model to Digital Native and Immigrants or Millennials could be the one by Vygotsky (1978), who supported that one of the most important elements of learning is social interaction. Research on technology use should not just focus on models that put the digital devices in the centre of a theory, but instead, technology should be explored in relation to the people who play a role in the process of learning how to use digital devices. The model of learning that Vygotsky (1978) suggested based on culture, social factors and the role of adults, although older than the models that focus on technology, it is still valuable in research that investigates how technology is used by children and this is shown on this thesis. One of the most important aspects of this thesis is the development of the Educational Digital Divide model, which is based on research based evidence gathered in studies 1-4, and it is the model that the thesis suggests as a better alternative option to frameworks like the Digital Natives and Immigrants.

The aim of this thesis is to help educators understand better the relationships between the digital experiences of children and teachers and their ways of using Online Maths Websites through the lenses of the Educational Digital Divide and the Digital Natives and Immigrants. Research shows that there is a diversity of experience and attitudes towards digital technology. It is not the case that all young people are fluent in the use of digital technology. With the advent of more and more digital technology in education it is important to investigate whether these differences have an impact on the beneficial effects of this technology.

As identified in the introduction of the thesis and in this chapter, there is a clear gap in the knowledge that educators and academics have in relation to how digital experiences of children are linked to the ways children use technologies for purposes of school and assessment in primary schools and whether the interaction with technologies is related to performance. However, the recent changes in educational assessment in the level of primary schools with the introduction of the online multiplication tests in Year 4 makes the gap of this knowledge quite prominent. This thesis intends to fill this knowledge gap with useful information for teachers, parents and people who work in the Department for Education.

3. Study 1

3.1 Introduction

Part of the thesis introduction discussed the fact that there is limited research exploring the uses of assessment through technology by primary teachers and students. Researchers (Pellegrino & Quellmalz, 2010; Whitelock & Watt, 2008; Winkley, 2010; JISC, 2010; Schwartz & Arena, 2009) have written about the advantages and the challenges of such an integration of digital technologies in educational assessment, but what is missing from this literature is the voice of teachers and students and information in relation to what kind of technologies they use for purposes of assessment. For that reason, the first study of the thesis was an exploratory investigation of what is the current situation in primary schools in relation to the use of technologies in assessment and what would be the best way forward, the most interesting aspect of the topic that can be explored further in the next studies of the thesis.

The main aims of this first study were to determine if teachers and students use any kind of technologies in assessment practices, what they think about the use of digital technology in assessment and any potential differences in students' feelings and performance from the introduction of technology in assessment. The first part of the study explored the tools they have used in their school and how these are used for assessment purposes. The second part of the study investigated teachers' and students' thoughts, ideas and perceptions about the use of digital technologies in assessment activities and the third part explored how students felt about potential integration of technology in assessment practices.

The research questions were as the following:

- What are the primary teachers' perceptions and experiences regarding technologies in educational assessment?
- What are the primary students' perceptions and experiences regarding technologies in educational assessment?
- In what ways does the integration of technology into assessment affect students' feelings and performance?

3.2 Method

3.2.1 Design

The research followed a qualitative approach focused on the teachers' and students' experiences and perceptions regarding digital technologies in educational assessment. The main reasons for choosing primary schools were the fact that there is no much previous research on the specific level of education, but also the fact that the assessment process is not as structured as the secondary school curriculum and the removal of levels from the UK curriculum gives teachers of primary more freedom to try new ways and methods of assessment. The removal of levels has made the integration of technology into assessment easier, and also, it makes the exploration of the current situation regarding assessment in primary schools even more interesting. In addition, Bruckman, Bandlow and Forte (2002) argued, *"children between 7-10 years old are the most effective prototyping partners and they are verbal and self-reflective enough to discuss what they are thinking*" (p.16). Thus, these ages were deemed the most appropriate for this study.

3.2.2 Case study

The research included a case study involving two primary schools from Bath and Bristol. According to their Ofsted reports, one of the schools was overall good, while the other one required improvement. Drawing on Punch's (2009) chapter about case studies and generalizability, it should be mentioned here that the purpose of this study was not to generalise the results of the research to the whole primary school population, but to develop an in depth understanding of the current situation in relation to ICT and assessment in primary schools. The particular geographical area was only one, unique case among many others in the UK. However, it had also common characteristics with other primary schools and so made these findings potentially transferable to other schools.

3.2.3 Interviews

Punch (2009) argued that in qualitative research the most important tool for data collection is the interview, which gives the researcher access to the meanings, perceptions, definitions of situations, and constructions of reality of the participants. More specifically, he argued that the interview "*is one of the most powerful ways of understanding others*" (p. 144), while Jones (1987) also claimed that an in-depth interview can offer rich data to the research. In addition, an important reason for choosing the process of interviews was the fact that, as Cohen, Manion and Morrison (2011) suggested, "*it is important to understand the world of children through their own eyes rather than the lenses of the adult*" (p.433) and children's thoughts and experiences were deemed essential for this project.

The interviews for this study were semi-structured for both students and teachers, as it was considered important the interview protocols to be flexible and adjustable to meet the needs of the different groups of participants; children and teachers (Punch, 2009). The researcher prepared two different interview protocols and questions and conducted pilots with both children and teachers in order to make sure that each group was treated in the best possible way for its participants (Cohen et al. 2011; Punch, 2009).

During the interviews, the researcher tried to develop an equal relationship with the participants in order to make them feel comfortable, by modifying the language so it was appropriate for their age group; showing interest in what they were talking about and making eye contact when they answered a question. In that way, the researcher tried to make the participants more open to answer all the questions eagerly and more honestly. In addition, the fact that the interviews were semi-structured and did not have to follow strict guidelines, helped the researcher build a more relaxed atmosphere between her and the participants, and the interview process was more of a conversation in which the children and teachers could express their thoughts freely. Lastly, the participants were also made aware that the researcher herself was a primary teacher, which helped with the elimination of status differences.

Since the duration of an interview for children should not be more than 15 minutes for each child (Cohen et al. 2011), the interviews for the children in pairs were planned to last approximately 20 to 30 minutes, while the interviews with the individual teachers were planned for 30 to 40 minutes. The students took part in the interviews in pairs, apart from one case, where the students were in a group of three. The main aim during the interviews was to gain as much data as possible, but at the same time not to make the participants feel bored or uncomfortable. The interviews had three main parts. The first part consisted of questions about the use of digital technologies at school, the second part had questions about assessment and the last part had questions about technologies in assessment. The first and the second part were shorter, while the third part was the main one and lasted longer.

The students were asked about their thoughts regarding assessment and the use of technology in school, while some of the interview questions were also focused on how they feel regarding assessment. For example, "*What is the best and worst part of assessment at school?*", "*Which of the subjects you are taught in your class, do you think could be assessed using a technology like a tablet, or a computer?*". The interview questions for teachers explored their awareness regarding the use of ICT in educational assessment and their ideas of any future use. For instance, "*Do you use any of the technologies you mentioned earlier in assessment activities, or for assessment purposes?*", "*Regarding on screen assessment, would that make any difference to your students if they took the same test that they usually take on paper, on screen?*".

(The interview protocols of both students and teachers can be seen in Appendix A.)

3.3 Participants

The participants that took part in this first study were 14 unpaid volunteers from 2 different schools. More specifically, there were 9 students from Years 4, 5 and 6 (9-10 years old) and 5 of their teachers. The teachers were also from Years 4, 5 and 6 and they were the ones who chose the student participants of the study. The teachers were asked to select children who were interested and wanted to talk about the topic. From the 5 teachers, 3 were female and 2 male, while from the students, 5 were female and 4 male.

3.4 Materials

The interviews with the students involved two different activities. For the first activity, the materials used consisted of two collages of pictures. For the second activity, the materials were white address labels (stickers), used as name badges.

Figure 2 Paper based assessment

Figure 3 Technology based assessment

The first activity collected data with the use of the projection technique (Cohen et al. 2011; Greig, Taylor & MacKay, 2007). The students were shown two collages of pictures that were relevant to the topic and they were invited to express their ideas about what they think the students are doing in each case. The first collage (Figure 2) had images of students taking exams in the traditional way with pens and papers and the second collage (Figure 3) had images with students being assessed using different kinds of technologies. This technique was used to reduce the possibility of biased answers and was designed to trigger responses that were more authentic and assisted avoiding leading questions.

For the second activity, the students were asked to take part in a role-play activity. The decision to include a role-play activity as part of the interview process with the children was taken based on the fact that role-play can be an important tool to gather children's perspectives effectively, as it can assist children to express their feelings and thoughts freely and clearly (Clark, 2005; Kakos, 2005). Taylor and Walford (1972) have identified motivational, but also learning advantages that role-playing involves, such as the increased interest and excitement by the participants, the level of novelty and freshness that the role play offers to the data collection activity and the transformation of the relationship between a pupil and a teacher, together with learning benefits in cognitive, social and emotional levels. Hamilton (1976) has identified different methods and categories of role-playing based on whether the activity includes a passive or active role, whether the participant has to give verbal or behavioural responses, and whether the participants have to imagine, act or react to a situation. According to Cohen et al. (2011), role-play is used in exploratory research studies that explore human social behaviour where the main aim of the researcher is to gain raw information of how the participants think and feel and it should be used in combination to traditional research methods and not as a replacement of them (Ginsburg, 1978; Kakos, 2005).

For this study, the children were asked to take part in a passive, imaginary, verbal role-play activity. They were given address labels in order to write their names accompanied by the title Mr. or Mrs. and they had to imagine being teachers themselves and give some ideas on how technologies could be used in the assessment of their units. More specifically, they were asked to describe what kind of test (paper based or with technology) they would give to their students in order to assess a subject of their choice.

The role-play activity aimed to make the children distance their own views from the given situation (the use of technologies in assessment) and try to think more critically experiencing the given scenario from the perspective of a teacher who has to think beyond basic elements of technologies, such as entertainment. Another purpose of the specific activity was to empower the role of the children in the interview and decrease the difference between them and the researcher who was asking the questions (Cohen et al. 2011; Eder & Fingerson, 2002; Kakos, 2005).

The interviews with the teachers' were recorded with an audio recorder, while the students' interviews were recorded with a video camera, with an exception of the last group of students, where one of the students said that he did not feel comfortable with the camera, so the audio recorder was used as an alternative.

3.5 Ethics

The research followed the ethical frameworks used by the University of Bath and the British Psychological Society (BPS) and was approved by the Ethics Committee of the University of Bath; Reference Number 15-048). In addition, since the study used a qualitative approach to the use of technologies in educational assessment and the data collection methods included interviews, the research also followed the ethical guidelines for educational research by BERA (2011).

Students, parents and teachers were given information sheets and consent forms that explained in detail the aims of the research, what is expected from them, and the fact that they have the right to withdraw from the interviews at any time, without any consequences. At the end of the interviews, a debrief sheet was given to the participants for more information regarding the background of the research.

All the participants were informed that the collected data would be stored safely and only the researcher and the supervisors will have access to it. The research data was collected, managed and maintained in line with the relevant law. The participants were asked to give their consent for some of the collected data to be used for further research and inclusion in educational journals or articles. The data collection method and the storage of the data met the requirements of the Data Protection Act (1998).

3.6 Procedure

All participants, teachers and children, were interviewed by the researcher at their own school during working hours. As mentioned above, teachers were interviewed individually, while the children were interviewed in pairs. Before the start of the interviews, the participants had a short briefing about the aims and stages of the interview, their rights and issues of confidentiality and they were given time for questions and clarifications.

3.6.1 Interviews with children

The choice of interviewing the children in pairs was taken because it has been found to be more useful with young students, as the presence of a friend and classmate encourages interaction and provides a more comfortable setting for the children and the researcher (Greig et al. 2007). Pair interviews offer students the chance to be more talkative, active, and challenge each other's responses, which is more difficult for a young student if he/she is alone with the interviewer (Cohen et al. 2011).

The time of the interviews was agreed with the teachers in order to be the most convenient for all teachers and students and in all cases the interviews were held during the afternoon. The participants were interviewed in their classrooms and the choice of the school environment was based on the fact that it is better for the students to be interviewed at a place familiar to them, where they feel comfortable and are less distracted by the surrounding items of the room (Cohen et al. 2011; Greig et al. 2007). In fact, Hill, Laybourn and Borland (1996) suggested that children feel even more relaxed when they are interviewed at their school than at home.

More specifically, at the beginning of the interviews, the children were welcomed and thanked for taking part in the study. The researcher explained the purpose of the interview and highlighted the most important parts of the information sheet, particularly their right of withdrawal, issues of confidentiality and the structure and length of the interview. The format of the interview included three main parts, (i) the use of digital technologies in schools, (ii) assessment in schools, and (iii) two activities. The students sat next to each other in front of a table where they could interact with the material given to them. The researcher was sitting next to the children, at the end of the table. The recorder was placed on the side of the table in order the children not to get distracted by it during the interview. As described in materials, during the first activity the students were shown 2 collage pictures with images related to assessment and technologies and during the second activity they played a role game, where they took the role of the their teachers. At the end of interviews, all students were given pencils and rubbers as a thank you gift for taking part in the research.

3.6.2 Interviews with teachers

The teachers' interviews were an individual, face-to-face verbal interchange of thoughts and ideas and were aimed to capture their perceptions and experiences regarding the use of digital technologies in educational assessment. The interviews were audio-recorded and had three parts: (i) the use of digital technologies in schools, (ii) assessment in schools and (iii) digital technologies used in assessment. All interviews took place at each teacher's classroom. At the beginning of the interview, the researcher explained the purpose of the interview and highlighted the most important parts of the information sheet, particularly their right of withdrawal, issues of confidentiality and the structure and length of the interview. At the end of the interviews, the teachers were given a box of chocolates and a thank you card for their volunteering participation in the study.

3.7 Method of Data Analysis - Thematic Analysis

The data were analysed with the method of thematic analysis which was developed by Braun and Clarke (2006). This method is used for *"identifying, analysing and reporting patterns (themes) within data*" (Braun & Clarke, 2006, p.79). The data are organised in *themes* and *codes* in order to represent the most important aspects of the data; *themes* offer answers to the research questions by presenting a detailed description of the patterns that are most important from the data, while *codes* are tags, or labels that represent the meaning of the collected data (Basit, 2003). The research followed a theoretical thematic analysis (Braun & Clarke, 2006), as the topic was driven by the researcher's theoretical interests in the area, the research questions were formed before the analysis of the data and they were based on previous literature, and some of the themes were also developed from work by Oldfield, Broadfoot, Sutherland, and Timmis (2012). For example, some of the themes represent the advantages and disadvantages of technology use in assessment, how students feel about tests (Murphy, Lundy, Emerson & Kerr, 2013) and exams and teachers' training (Davies, Collier & Howe, 2014).

The analysis followed the six steps outlined by Braun and Clarke (2006).

1. The first step included the familiarization of the researcher with the data through careful reading and transcribing of the collected data and taking notes of first ideas arising from the transcripts.
2. The second step included searching of the primary codes that emerged in the data and could correspond to the codes that were found in the literature review. The researcher took notes and highlighted all the relevant codes on the transcripts.
3. The third step included finding the codes that are related to each other and could form a group of a specific theme. Some of the themes were driven by the literature review; for example, the benefits and challenges of integrating technologies in educational assessment.
4. The fourth step included the design of maps with the themes and codes that were addressing each research question. The maps included both the themes that were identified by the literature, for example; students' feelings and teachers' training, and the themes that emerged from the codes, like stress, anxiety, and issues about training as a generational skills' gap in order to identify possible matches between the themes from the literature and the data.
5. The fifth step included finding representative names of the themes in order to represent the codes and answer the research questions.
6. The sixth and final step included writing the analysis of the data with the most representative examples of data extracts in the chapter of the study.

3.8 Results

This section presents the key findings of the research. In particular, the first part refers to the experiences and perceptions of primary teachers regarding the use of technologies in educational assessment. The second part includes the students' experiences and perceptions about the same issue and the third and last sub-section concerns the ways that technologies could influence students' feelings and performance in educational assessment.

3.8.1 Primary Teachers' Experiences and Perceptions of Technologies in Assessment

In order to explore how teachers use and think about technologies in assessment, they were asked about each topic separately. As it was mentioned above, the teachers' interviews had three main parts. The first part was about technologies, the second about assessment and the third about the interplay between the last two.

3.8.1.1 Teachers' experiences of Assessment and Technologies

The experiences of the teachers regarding the use of technologies in educational assessment were grouped into five main themes as seen on the table below.

Table 2. The use of technologies in Educational Assessment in Primary Schools

Uses of technological tools in Educational Assessment in Primary School	Technologies available in school
	Administrative use of technology
	Homework (online and on whiteboard)
	Tracking real time progress
	Internet as a resource of information

According to the interviews, there is a wide range of technological tools, software and websites (see Table 3), that teachers use on a daily basis in schools. However, as was mentioned in both schools, tools like laptops, iPads and robots, are not always available in the numbers required for all students. They have to be booked in advance for a specific lesson. They can be used only by one classroom at a time, and they are usually shared between two, or three pupils. The uses of those tools and software vary according to the purpose and the aim of the teaching. For example, the main use of computers and laptops is for the students to do research on a specific topic.

Table 3. Technological tools and Software/Websites used in Primary Schools (June 2015)

Technological Tools	**Software/Websites**
Interactive Whiteboards Computers Laptops iPads Projectors TV Digital cameras Electron microscopes Lego Robots Pro-bots and Bee-bots Data loggers Visualizers	Movie Maker/ iMovie Lego mindstorms Mathletics/ My maths Microsoft Office (Word, Power Point, Excel) Kodu/ Scratch Stop animation Dragon Voice recognition Nessy SIMS Target Tracker/ School Pupil Tracker YouTube Gps GeoCAS Phonics Play Google (Web, Images, Videos) Google Chrome Google SketchUP Audacity Clicker 6 Super 7 QR code reader eLiM Education Technology Think you Know Touch Type Test Base

All teachers mentioned that the main and most common way technology is used in assessment is for administrative work. All teachers said their schools had bought software for students' data input, which enables them to record what a child can do and record their attainment and progress. More specifically, they use different kind of programs to input students' data, check the targets and criteria that pupils have achieved, or have not achieved, in order to know if they are above, on, or below expectations. The software gives teachers a report with the pupil's progress and makes the data analysis easier for them.

The second most common way technologies are used in assessment is for homework. Technology is used in two different ways for homework. First, teachers give students weekly homework from online websites. These website give teachers the opportunity to set different homework for each student according to his/her abilities and the teachers can have all the data and the records of what students did and where they went wrong on every task. As teachers stressed, these kind of websites assist them to limit their marking time and plan in more detail the next lessons according to the students' needs. Second, technology is used for homework is when the homework requires further research. Teachers give students the opportunity to choose whether they want to do their research using their exercise books, or using computers. The students that choose to use a computer conduct their research online and prepare a PowerPoint presentation that they later present in their classroom on the interactive whiteboard.

Digital technologies can also assist teachers in assessing their students more accurately, because they give them the opportunity to track the students' progress in real time. This tracking can be done through many different ways such as (i) the use of tablets for real time recording of answers and discussions that emerge during the activities, (ii) the use of online websites for practicing the knowledge acquired of a new topic, (iii) the use of robots for testing the students' coding knowledge. For example, during some Maths lessons, students are first introduced to algorithms, then they are asked to write some instructions for the robot to move from the place x to the place z and as they do the task they apply and test their knowledge of Maths. Students write the code on the computer, download it on the robot and run it to see if their code was successful. This method offers them instant feedback and the opportunity to change and transform their code when it does not work.

Moreover, all teachers referred to the use of the Internet as one of the main resources of information for students' assessment. Teachers turn to the Internet to find specific information, guidelines and resources that will help them organise and plan the way they assess their students. During the interviews teachers mentioned that they use specific websites in order to have access to a great number of SATs test questions, mark plans and comments from examiners in maths, science and English. The resources are easily accessible online and teachers can just download and print all the material they need really quickly.

> *"In terms of doing research on computer I just think you can find out so much more because especially with the new curriculum coming in last September, we don't necessarily have enough topic books for the new topics that we have to cover. So, the Internet was kind of the best source of solution."*

Teacher 4

3.8.1.2 Teachers' perceptions of Technologies in Assessment

During the interviews, teachers expressed their ideas about what technologies could offer to educational assessment and what are the challenges of integrating digital technologies in assessment activities. The themes (Table 4) that emerged regarding their perceptions are the following: (i) advantages and challenges that come with this integration, (ii) suggestions and solutions regarding the challenges, (iii) the role reversal of students and teachers in relation to technological skills, and (iv) the suitability of the school subjects taught in primary school regarding technologies in assessment.

Table 4. Teachers' perceptions of Technologies in Assessment - Main Themes

Teachers' perceptions of Technologies in Assessment - Main Themes -	Advantages and Challenges
	Suggestions and Solutions
	Reversal role of students and teachers
	School subjects' suitability

(i) Advantages and challenges of using technologies in Educational Assessment in Primary Schools

The Advantages and challenges that the teachers referred to during the interviews include further specific subthemes which are analysed in this section.

Table 5. Advantages of using technology in Educational Assessment in Primary Schools

Advantages of using technology in Educational Assessment in Primary Schools	Instant feedback
	Quality of teachers' work
	Quality of students' assessment
	Quality of students' experience

One of the main advantages that was mentioned by all teachers was the fact that technology offers them instant feedback on students' progress. Technology provides teachers with real time evidence of what the students have understood and what are their misconceptions, or the points that need further explanation. This instant feedback gives them the opportunity to assist students to overcome their mistakes instantly, rather than having to wait for the teacher to mark the exercises and bring them back to school. Thus, digital technology provides teachers with instant information concerning students' progress and offers them the chance to provide immediate intervention in case of misinterpretations.

Teachers also argued that technologies improve the quality of their teaching. Based on the instant feedback they receive through technologies, they can plan and adjust their lessons depending on the students' specific needs. Marking time is reduced and this gives teachers more time for planning and preparation. Most of the websites and software give them the chance to produce summative reports for the students' performance instantly without having to write all the paperwork themselves. The fact that data is online enables the teachers to access this information from anywhere with Internet access. Furthermore, teachers' work is enhanced, since technology offers them a variety of solutions for students with special educational needs (SEN). For example, they can work with text, audio, visual images and videos depending on the needs of the student. Moreover, technological tools and websites provide teachers with the opportunity to give students tasks which are adjusted to the students' individual needs rather than giving the same tasks to everyone.

> *"Doing their homework online, works really well, because it supports them in the way that they can go back and review things and because it gives them that instant feedback. So, they don't have to wait for me to mark it and hand it back to them. Also, it means it cuts on our marking, because if then we had to mark every week their homework, there are 28. That would be 28 more pieces of work. So, yeah, it's really handy and technology is great in that way."*

Teacher 4

The last factor was the use of technologies in assessment reduces the consumption of paper. This factor was not mentioned by all teachers, but emerged as an issue that could help reduce the schools' budget in the future. Technology could cut down the paper cost. Digital technologies are more expensive to buy than buying ink and paper, but the teachers mentioned that it could be beneficial in the long term and the money saved from paper could be invested in other tools and equipment that would make their work easier and better.

Teachers also referred to the benefits that technology offers to the students in terms of the quality of their assessment. Most of the websites and software that are used by students for their homework, provide instant feedback and hints/help quotes on how to continue on a task, when they face problems and do not remember what the teachers said during the lesson. In that way, students have constant assistance through the use of the software at home, which they normally would not have. Students can also track their own progress and build on their self-assessment, as technology offers them the opportunity to see their grade in real time, review, practice their knowledge and skills and try again. For instance, when pupils program or code the robots in the classroom, they can see in real time if their programming is working (if the robot does what was programmed to do) and if not, they go back and change the code and try again. All these trials and errors and feedback assist students to have a more detailed and precise idea of their own knowledge and understanding.

> *"Children can log in, they can go on their account, track their progress and do all sort of things..."*

Teacher 5

Similarly, technology provides students with the opportunity to apply their knowledge and understanding to real life scenarios evaluating their practical and problem solving skills. As teachers argued, when students use technologies in a real situation, their understanding of the situation is developed significantly and that improves the quality of their assessment too.

> *"So, this technology is really helpful for the children and it is using this robot here. So you do the programming on the computer and then you download it on to this robot. So that gives them amazing skills, like practical skills and programming skills that they can apply to other things."*

Teacher 1

The practical and problem solving skills are also part of the 21st century skills, which according to teachers, are of primary importance and should be integrated into teaching and learning and they suggested that the use of technologies can assist in the assessment of those skills.

> *".. I think we need to be steeling problem solving skills and we need to ensure that the children have got the ability to persevere, become more resilient, lot kids just fail at the first tests because they are not just very good in applying themselves and also, not steeling in kind of full sense of self-believe, but just building up their self-esteem in a realistic way and explore where actually kids are good at and developing that. Not say that you shouldn't introduce new skills, but I fear that we are not actually gearing our kids up to be effective in the world that they are going into."*

Teacher 3

Another main issue mentioned by all teachers was related to how students experience technology based assessment. Teachers thought that all students would enjoy the experience of using technologies for assessment. Technologies would keep students engaged and hold their interest throughout the whole assessment activity, because it is a more "child-friendly" way of assessing.

> *"They all have to do their homework on My Maths (website)… I think they enjoy it, because a lot of them see computers as something fun and exciting. I think it makes it a lot more interesting than if we were giving them homework sheets… it's much more engaging and kind of child friendly as well."*

Teacher 4

All teachers believed that students would prefer to be assessed using a technological tool than having the traditional paper-based assessment. Only one teacher mentioned that students would choose technologies only if they knew how the whole assessment procedure works, which is closer to students' actual opinions.

However, the integration of technologies in assessment practices also involves challenges for both teachers and students. The challenges are categorised into the following subthemes (Table 6):

Table 6. Challenges of using technology in Educational Assessment in Primary Schools

Challenges of using technology in Educational Assessment in Primary Schools	Accountability and control of assessment
	Students' familiarity with technologies and technological skills
	Teachers' training and fear of technology
	Practical issues

The first and main issue that was raised in all interviews with the teachers is the fact that students' assessment is highly accountable and controlled by external bodies, like the Department for Education and Ofsted, which means that teachers cannot change the way they deliver the summative tests (SATs and optional SATs) at the end of the year. The tests are controlled by the government and the instructions for those tests require paper based assessment, the assessment throughout the year should follow the ways that SATs are delivered. It is of primary importance for the students, the teachers, and the school as a whole, the preparation of students to line with the way SATs are held, so the children are prepared to succeed specifically at these tests. In addition, there is an uncertainty regarding assessment and how the new curriculum will affect tests and exams as well. This uncertainty meant that the teachers preferred to continue with what they have been doing over the last few years rather than experimenting with new ways which might not be successful.

> *"In years 2 and 6 they (SATs) are still a definite requirement that every School has to do. A few years ago we boycotted it and lots of schools chose not to do it, but we did it here, but some schools chose not to do it, because they just felt that children were being tested too much. But you know, we've got a new government and we've got to do it. So, what will happen next year is... Well, I don't know about that yet..."*

Teacher 1

> *"It's all paper, yeah, it is still quite old school in that regard. There is no like formal government tests in electronic format."*

Teacher 3

Teachers suggested that even if some of their students would be happy to take tests on computers or with different technologies, the important factor that influences this integration of technologies in assessment is how familiar the students are with the technological tools used for the assessment activities. According to all the teachers, students' familiarity with technologies and their technological skills vary greatly amongst the students.

> *"I think it varies widely. Some have got mobile phones and tablets and things like that at home and are really heavily into it and obviously they have a lot of exposure at it at home and there others that, I think, they barely have a clue."*

Teacher 4

One reason why the technological skills of students vary so widely was the fact that, according to teachers, there are still some students who do not have access to technologies like computers, laptops and the Internet at home, which influences their technological skills. Thus, sometimes it can be difficult for teachers to set homework that requires the use of computers or connectivity to the Internet, because it will not be fair for all the students.

Furthermore, teachers mentioned that students might appear quite skilled in technologies, because they know how to use the equipment and how to navigate a website, but they lack typing and word processing skills, which are essential when they have to write their assessment during a timed test. Teachers argued that students might be good at research and the social media tools, but they are less familiar with word processing software. Moreover, some students find reading on screen difficult and tiring. As a result, students who are not familiar with the technological tool would face difficulties during a technology based test.

> *"They are very good at research and using the Internet, they are less good at using Microsoft word and Power Point and things like that and typing. I have got some very good ones, but there are some that still find typing very hard and are still quite slow at it. So, they are good at all the social media stuff, but less good at the Microsoft Word and things like that."*

Teacher 2

Training is one of the most important challenges for teachers' regarding the use of technological tools in assessment. According to them, this is a generational issue, because the young teachers are trained to use the new equipment and they are quite confident with technology, while the older teachers who have had no training have to use their own time to learn how to use different programs and technologies. All teachers said that they would welcome extra training and support on how they could use technologies in assessment activities.

> *"So, you know that basically you've got to plan, there is so many things to do, that probably that is the last thing on people's list and yes, there is no training, cause there is no money... So, yeah,*

I don't use it as probably, as much as I could, but there is probably things on the interactive whiteboard that I don't know about and like filming things and getting children to edit it.. I would love to do more, but there is no money..."

Teacher 1

More specifically, teachers said that if they want to use technological tools in their assessment, they have to invest their own free time, to find out what could be beneficial and then try to implement it in the classrooms. All this requires extra time, work and experience, which they do not have and so, they prefer to continue what they were doing without the technology.

"I think that you need to just put time in it to do it on your own time, which is... You know...No one have got any time to show you how to do things. So, you are just learning on your own, or just sort of learning as you go through, which isn't, you know, isn't ideal.."

Teacher 1

"I still think that it is a kind of fear factor and some people just hold themselves back, cause they just don't like change and so on.. You always have that degree of kind of friction in any kind of organisation."

Teacher 3

One of the consequences from this lack of training is that teachers do not trust the technology. Teachers referred to problems like the compatibility of the devices and more specifically, their fear that sometimes different software are not compatible on some of their devices and they could lose their students' records without knowing how to recover them. For example, most of the time the technology at schools is quite old, while their own personal devices are new. Often the software they use for data input does not run on both home and school devices and they cannot mark, or do analysis at home. In addition, they also mentioned that technological tools could be unpredictable and lead to situations that they cannot handle easily, which, in a case of a test, is very risky, as everything should work perfectly for the convenience of the students.

> *"Technology could be sort of unpredictable.. Your laptop can run out of battery suddenly or the website you are using can crash, or you know.. and if you would set aside a lesson to do that and then something happens, then you couldn't' do your assessment online or on the computer."*

Teacher 4

Another concern was that when children use the Internet for research purposes outside school, they have to be very careful in terms of assessing and marking the students' projects, especially, if they are not familiar themselves with the research online. Many times, pupils find information on the Internet and they just copy and paste it into a word file, or onto a power point slide, without reading the material, or changing and adding their own words.

The practical issues concern the lack of equipment and money. Both schools mentioned that they do have the basic equipment (e.g. whiteboards, computers and laptops), and the equipment the school has is not always available to use because it is already booked in advance, or it is old and does not work properly. However, sometimes even having all the laptops the school has is not enough and students have to share. Thus, taking individual tests, like SATs, on the school computers would not be feasible. In addition, the amount of money that each school has for technological tools is limited and they cannot always buy the equipment they want.

> *"We have not really got any equipment to do more than what we already do."*

Teacher 1

(ii) Suggestions and Solutions

During the interviews, the teachers provided some suggestions and solutions for some of the challenges that they mentioned. More specifically, the challenges concerning training of the teachers and the students' technological skills and familiarity with assessment activities that include technologies.

One of the schools addressed the issue of teachers' training by appointing a teacher as the ICT coordinator for the school. The role of the ICT coordinator was mainly to offer support and training to the teachers of the school regarding the use of new technologies in teaching and the new ICT curriculum in programming and coding. One of the coordinator's responsibilities was to manage the technological equipment budget of the school and decide where the money should go and what should be bought. Most of the time, the choices that the coordinator made were based on research, or discussion with other teachers.

To address the issue of students unfamiliarity with technology one of the schools has established an after school club. The after school club gives students the opportunity to work on their homework or their project on the computers at school, either alone, or with the help of a teaching assistant. Alternatively, if the homework is not compulsory, or the school does not run a homework club after school, then the teachers give the students the option to choose whether they want to work either on computers, or on their notebooks.

> *"So, we kind of give them the choice, cause not all children have computers at home, where they can produce power points or have a memory stick, or the support from the parents to do that. So, we give them the choice."*

Teacher 1

The issue of students' technological skills, and especially the speed of typing, could be addressed if the pupils were taught touch typing. Teachers do not teach students touch typing due to lack of time. In one school, the students were given a touch typing activity during the ICT subject and in the other school, the students with SEN were given touch typing lessons.

> *"So, we have taught them (SEN students) touch typing and as soon as they can touch type, it doesn't hold them back at all."*

Teacher 1

However, in both schools the teachers recognised the importance of touch typing and the fact that students will need to know how to type, quite soon, for their projects at secondary school and for their future after school. Therefore, all teachers were quite keen on introducing a program to teach touch typing. They also recognise that touch typing could be a strong alternative for students with handwriting difficulties.

> *"I think that touch typing is really important, cause you could look at it that way, if you would apply for jobs, you would type... you know, and the children when they are quite little, you know, they are using one finger and it can take them quite a long time.. Getting them to use that is great! So, again, it's a lot of time restraint on it, but when we do get time, I do have a group having some sort of touch type activity."*

Teacher 5

The familiarity of the students with the use of the technological tools that could be involved in assessment practices was something only mentioned by one teacher. However, the following statement by the teacher is quite representative of what could be done in terms of the integration of technology in assessment.

> *"If you are going to assess the children using technology, you would have to use very similar technology all the way through the year, or consistently, so that they were used to it at the end... because, if you suddenly put something new in front of them, I think, that would stress them out more. So, I think they would feel more comfortable, but only if you would use it consistently throughout the year or they got used to it at a young age."*

Teacher 2

(iii) Reversal role of students and teachers in relation to technological skills

Another issue that emerged from the interviews with the teachers was the reversal role with the students. Teachers mentioned that they feel students are more skilled using technologies than themselves.

> *"I mean, you know the idea of digital natives and you know, digital immigrants, I mean, I am sort of in the gap really. So, I am fairly aware of technology, but you know, I didn't grow up with*

the Internet, but it's part of children's lives. So, it's strange... You know... You've got kind of reversal roles where the children are often more skilled than the teacher, cause it's just second nature to them."

Teacher 3

More specifically, teachers argued that children grow up with technologies all around them, which makes them skilled in the use of technologies. It is an essential part of their lives and there are times that they know more about specific programs and software than the teacher of the classroom and they even offer to demonstrate what they know, which according to the teachers is quite useful.

".. and if I am not sure, I will go to our ICT coordinator or sometimes some of the children have used the program before and feel really confident with it, so they are really happy to demonstrate to other children."

Teacher 4

In addition, students are going to be assessed on screen or with the use of technologies in their future adult life, thus getting used to it and getting experience of technology, could be quite beneficial for them. Already, a lot of training is delivered and assessed electronically, and students are not prepared for this kind of testing and assessment. This lack of preparation is also due to the fact that the assessment system has quite a narrow view of testing, which is not tailored to assessing the strengths and weaknesses of the child.

"One thing I always find interesting is that when we assess, it is a very blank tool, whereas all the teaching we deliver is tailored to the child, but when it comes to actual assessment, we never tailor assessment and I just wonder if that could be a total changing approach.. That might happen over time, where people will take into account people's strength, cause at the moment, you are really testing a child's ability to sit a test. You should

certainly have rigour and you should be diligent and so on, but I just feel, when it comes to testing, it's very crude I think."

Teacher 3

(iv) School Subjects

The subject that was deemed to be the most suitable for the integration of technology in assessment is Maths. All teachers agreed that Maths could be assessed easily on screen, or with the use of different technological tools and software. Other subjects that could also use technologies in assessment are Science, ICT and some of the foundation subjects like Geography, History and French.

However, subjects like English that include interpretation of responses by the teacher and where the assessment is quite subjective, cannot be easily assessed with online software or automatic marking. Writing requires a good typing speed, which is something that, as already mentioned, varies widely among the students. Thus, according to the teachers, writing and comprehension are not easily assessed with technology. Nevertheless, some aspects of English, like spelling, punctuation and grammar, could be easily assessed with a technological tool.

> *"I think definitely Maths would be good to do that on the computer and perhaps grammar.. I don't think writing necessarily, because that just comes from the child and they just writing it.. Perhaps science too, because it is good, cause you can have good diagrams, you can play them clips of different experiments and sort of ask them what is happening or what they predict is going to happen at the end… So, yeah, lots of subjects really, apart from writing, because writing is just very difficult to assess any way."*

Teacher 1

In general, what can be assessed with technology are subjects which require a right or wrong answer and do not require any further explanation and interpretation by the teacher.

One of the most important aspects that the ICT coordinator emphasized is that technology offers the opportunity for the assessment of students' skills across the curriculum, as in the following example with some small robots called bee-bots and the pro-bots.

> *"We will use the bee-bots for maths, cause we do position and direction and that is linked to literacy. So we will talk about algorithms, what algorithm is, but we will write a set of instructions, a sequence of instruction, so we will teach that through literacy and then we will use the bee-bots to program position and direction to find their way and we will look at forward and backward. So we try to link it, we try to link to other subjects."*

Teacher 5

3.8.2 Primary Students' Experiences and Perceptions of Technologies in Assessment

Students were asked about their experiences regarding assessment and technologies, and expressed their thoughts and ideas about the combination of technologies and assessment.

3.8.2.1 Students' experiences of Assessment and Technologies

The experiences of students are focused on the tools that they have access to, on their uses and the ways they are assessed. These tools, software and websites are the same as those reported in Table 3. However, when students were asked if they use any kind of technologies for assessment purposes, their responses were all negative, except for one student who mentioned that she had taken some online Maths tests at her previous school in Poland.

The explanation for these negative responses is because the uses that were mentioned by the teachers in relation to technologies and assessment practices (see Table 3) involved mainly the teachers as the facilitators of the assessment activities and not the students. In addition, students did not refer to homework presentations and the online homework as assessment, because, for them, the word assessment refers only to tests and exams. Thus, even if students do use technologies to do their homework on websites and present their work on whiteboards in front of the classroom, they do not count this use of technologies as part of their assessment. On the contrary, students' associations of technologies in the classroom are focused on ICT coding, educational games, research and teaching and learning in general across all subjects. Regarding the ways students are assessed, the most common method is tests, which are worksheets with questions that students take every term and are all on paper.

3.8.2.2 Students' perceptions of Technologies in Assessment

Students expressed their perceptions regarding the integration of technologies in assessment activities and the main themes that emerged were the following: (i) advantages and challenges of the use of technologies in assessment, (ii) suggestions and solutions regarding the challenges.

(i) Advantages and challenges of the use of technologies in assessment

Most of the advantages and challenges that students referred to during their interviews were consistent with their teachers perceptions (see Tables 5 and 6). The students' advantages and challenges were further analysed into the following subthemes.

Table 7. Advantages of using technology in Educational Assessment in Primary Schools

Advantages of using technology in Educational Assessment in Primary Schools	Instant feedback
	Quality of work
	Variety of Choices
	Quality of experience

The factor that seemed to be of great importance for both students and teachers is the instant feedback they receive when they are assessed using technologies. All students mentioned that they prefer to have the result of their test immediately after taking the test, because immediate feedback helps them to clarify what they have understood, what they have not understood and where they should pay more attention. In addition, they argued that when the software or the website is interactive and gives them hints or instant explanation of a response, then they are more likely to remember the correct information. When they get their test papers returned a long time after they have taken the test, the focus is only on the grade and not on the answers. They also mentioned there would be benefits for their teachers, because they will have access to all their answers immediately and they will be able to help the students that need extra support.

An advantage that was mentioned by all the students, several times through the interviews, was related to the quality of their work, and more specifically, how technology could improve the appearance of their test/work. Pupils argued that when they are working on a technological device, like a computer or a laptop, they have a neater piece of work. On the computer they have the opportunity to delete what they do not need instead of squiggle it. They can correct their answers easier and they have a less messy result. In addition, they also referred to the automatic spell checker which gives them the chance to correct their spelling mistakes having a flawless piece of work.

> *"When you are typing things it looks neater that when you're writing."*

Student 5

Furthermore, the use of technologies gives students the opportunity to choose how they want to present their projects in the classroom. Students rate the freedom of choice provided by technology highly. They can use their knowledge of technologies to present work in their classroom, but if they do not feel very comfortable using a Word or Power Point document, they can work on paper. In that way, they can use their skills in the best possible way to produce their work. Some of the options technology offers them include the creation of presentations or small projects, which include text, images, sound and videos making the work of the project or homework even more enjoyable and creative than the paper version of it. In addition to that, the choice that students are given between technologies and paper was considered by the students as of great importance, because it also assists SEN students. The students recognised that some of their classmates do not feel confident with reading or handwriting and taking a test on the computer, where they do not have to write by hand, would help them perform better.

> *"..because some people don't feel really confident about their reading and writing, so maybe doing it on some different technology might help them."*

Student 6

However, the variety of choices included also includes the level of difficulty on the tasks that are set on technological devices. Different students have different abilities and according to both teachers and students, the use of technology in assessment practices help them to find tests and activities that suit the students' needs best. For example, they mentioned that the website for Maths gives them many different levels of difficulty for their homework and they can try the easy level first and if they succeed, they can move onto a harder level. They can challenge themselves and test their skills without having to go back to school to check their work.

Among the variety of choices that students have when they use technology is also the accessibility of their work. Technology gives them the opportunity to access their online homework from anyway with Internet access. More specifically, students that use the website 'My Maths' for their homework mentioned that it is easier for them to access their work online. Especially when the website with the homework has an application version which can be easily downloaded on a tablet, they argued that they can do their homework even when they are in the car, or somewhere outside of home. They also mentioned that when homework is online they are able to do their tasks, even if they have forgotten their books in the classroom.

> *"We use 'My Maths' at home as homework and it is something that we can go on from anywhere; you log in with your school password and there are loads of different tasks for homework and I think computers are quite good in that way cause the teacher can set it online and you don't have to take it home. It's not a waste and it's much easier to access it instead of getting it out."*

> *"If it was an app, that would be much better, so if you are on holidays, you bring your tablet with you, a phone with you, and*

you might do your homework on an app and you are in a car and you can't access home."

Student 9

Another choice that technology offers in assessment, is that it cuts down the cost of paper. Students suggested that with that money, they can buy more technological tools, like computers and laptops and use less paper copies. They even mentioned that this will mean spending money for electricity, as those tools need charging, but they thought that it will be a good investment that will pay off in the long term.

"Now you have to buy paper constantly, but if you use a phone or a laptop, then... But, saying that a phone or a laptop need charging, but it will pay it back eventually... They will get the money back by not buying paper. It would be a good investment."

Student 9

In relation to the quality of students' assessment experience, both teachers and students claimed that technologies could improve the students' experience, not only in terms of enjoyment, but also in learning due to the possibility of instant feedback. Pupils argued that technology provides them with attractive and enjoyable rewards every time they get their homework right, which motivates them to continue working. The fact that the tasks set through the software or the websites are adjusted to students' needs and difficulties makes them feel comfortable with the level of knowledge they acquire and thus, continue working and feeling confident about their knowledge. All students mentioned that using technology for tests and exams would be a new experience for them, which would be very interesting, different than what they are used to, and fun. They mentioned that it is different to traditional paper exams and a whole new experience that seems really appealing to them.

"Everything electronic is more interesting than the paper test."

Student 9

However, students recognised that the integration of technologies in assessment could also bring many challenges (Table 8).

Table 8. Challenges of using technology in Educational Assessment in Primary Schools

Challenges of using technology in Educational Assessment in Primary Schools	Workings/ physical aspect
	Students' familiarity with technologies and technological skills
	Fear/lack of trust of technology
	Practical issues

Students' main concern was the fact that when they are assessed on computers and tablets, they do not have a way to show their workings to their teachers because of the lack of paper. Especially in subjects like Maths, students mentioned that doing the calculations in their head without taking notes was difficult. They argued that when they make notes on paper, they can understand and organise their thoughts more easily, while on the computer, they lose the physical aspect of pen and paper and the activity becomes more challenging. Students wanted to have the opportunity to write their notes down on paper and be sure that the teacher would actually see their workings.

> *"If you don't really have any ways to work it out and you have to be working it in your mind, it does get quite confusing, like, you get mixed up."*

Student 4

The second most common subtheme of the challenges that emerged through the interviews with the students was their familiarity with technologies and their technological skills. Students acknowledged the fact that some of their classmates do not have access to digital devices and the Internet at home. For that reason, they argued that if all of them would be assessed on technologies, the classmates who do not have access to technologies at home would be disadvantaged in comparison to those who have access to technologies at home and are more familiar, experienced and skilled on how to use digital devices. Thus, it would be unfair for those classmates to be assessed on technologies.

> *"There is a minus to having a test on the computer, cause then people who don't have a computer are disadvantaged, cause the*

other can type faster… and I think that is unfair for people who don’t have technology.”

Student 9

The issue of cheating was also connected with how well some students can use technologies and the students seemed quite worried about it too. For example, some of the pupils who are more skilled in using the computer, or laptop and the Internet could be tempted to go online or use the computer’s calculator in order to find help and answers for the tests. Cheating on a test is taken very seriously by the students and the use of technologies seems to give pupils more opportunities to cheat.

In addition to cheating, another issue that derives from students’ familiarity with technologies and their technological skills is typing speed. According to the students, the main factor that seems to separate the levels of their technological skills is how fast someone is typing. Students were mentioning that not all of their classmates know how to type with a sufficient speed and that put them at risk of being left behind. Especially in terms of assessment where the time is really important, typing issues would hold some of the students back and that would impact on their performance too.

Another concern that was raised by the students regarding technologies in assessment is fear/lack of trust of technology. Students mentioned that technology could be very unpredictable and expressed fears of losing all their work and answers of tests because a laptop would run out of battery, or a window would come up and they would not know how to handle the situation. Especially in the case, where they are taking a test, they want to be sure that everything will work perfectly and there is no risk of losing their test or their work in the middle of the exam.

“The worst that can happen is something goes wrong, cause technology is quite variable, it can run out of battery, or something can happen and you lose all your answers..”

Student 9

Students referred also to some practical issues that accompany the integration of technologies in assessment. The main practical issue which was mentioned by both teachers and students was the equipment and the fact that there are not enough devices like computers, laptops or tablets for all students. Pupils said that if they would have to take a test on the computer or laptop individually, at the same time, they would need more equipment than they have already. They were also quite clear that tests and exams should be taken individually and not in pairs. In addition, some of the images they were shown at the first activity during the interviews had students answering questions on their mobile phones and students said that they are not allowed to bring mobile phones at school, so this way of assessment would not be feasible due to schools' regulations.

Another factor of practical issues that was mentioned in the interviews with the students was the cost. The cost of the equipment, the cost of hiring people to upgrade the schools' website, so it can support online tests, and the cost of developing software and applications specifically designed for the needs and the purposes of students' assessment.

> *"They have to pay programmers to make it work."*

Student 8

Furthermore, students argued that another challenge would be the way teachers marked their work. The traditional way of using physical paper and checking the right and wrong answers seemed to them to be the most reasonable and familiar way of marking. Marking a piece of work or a test on a computer seemed a little confusing for students who mentioned that the teachers should know all the students' passwords and go online to find what they have done and then mark it.

Last but not least, some of the students were worried in terms of the responsibility for the equipment in an outdoor assessment activity. More specifically, they suggested that only the Years 5 and 6 of Primary School should have the opportunity to work with expensive equipment, like tablets and cameras, because the pupils in younger years were too young to be responsible for expensive tools. According to the students, this use should only be limited to the upper Primary School classes.

(ii) Suggestions and solutions

However, students also suggested some suggestions for the challenges that emerged through their interviews. More specifically, they referred to the challenge of familiarity with technologies and their technological skills suggesting that it would be beneficial for them to have more hours of the Information and Communications Technology (ICT) per week, or just use the computers and laptops more often during their learning and their formative assessment activities. In that way, even the students who do not have access to technologies and the Internet at home would be able to use the equipment.

In addition, in regard to fear/lack of trust of technology, students suggested having mobile rechargers with them or substitute devices in case anything goes wrong with the ones they will be using for assessment. The accessibility of the homework or the test would be even easier, if there were both a website and a downloadable version of application for the software they will use, so they can easily access it from many different devices and even without the need of Internet connection.

3.8.3 The ways that the integration of technology into assessment affects students' feelings and performance

When students were asked about their experience of tests and exams, they all referred to feelings of stress and anxiety (Table 9).

Table 9. Students' feelings about assessment

Students' feelings about assessment	Stress
	Nervousness
	Fear of failure
	Anxiety
	Panic

Students mentioned that they experience these feelings, from the moment the teacher announces that they will take the test, because they want to prepare, revise and get ready for it. These feelings become more intense before the exam starts and they reach the peak when the pupils start the test, while during it, they increase or decrease. The things that students are afraid the most of include strange, difficult or unknown words and questions, the possibility of forgetting what they know, lack of enough time, and the fact that they have to explain everything they write, otherwise they will not get the right grade. More specifically, this was the factor that all students mentioned and seems to be the most important one for all of them; to get a high grade. As they noted during the interviews, those feelings of stress and anxiety does not leave them until they receive their grade.

> *"I get really nervous and I just want to make sure that I get the right amount of things... I get really worried about it."*

Student 4

If the grade and feedback are good, then they feel happy and relaxed, but if the grade is not as high as they expected, then they feel stressed and worried because some of their classmates might mock them and they will be embarrassed and humiliated. It seems that all these negative feelings last for a long period of time.

> *"The tests also affect the people, because I know also people that come out of tests going 'oh, I am rubbish on this, I suck' and thinking like that, like 'I hate this', 'I am really bad at this' and not being very confident. So, I think it kind of affects people in that way, because if you have a bad score, it's totally the worst thing."*

Student 9

Nevertheless, it is worth mentioning that even though students experience stress and anxiety before, during and even after the tests and exams, they also regard tests as very important for their learning. Students acknowledge that assessment helps both themselves in terms of self-assessment, but also their teachers, as they know how effective their teaching was, what students have learned and who to support more.

> *"I think it is important because the teachers could check you or even you could check yourself if there is something more in to learn or in to practice."*

Student 5

The students were first asked how they feel about assessment in general and their feelings about the interplay of technologies and assessment. However, when the participants; both the students and the teachers, were asked if students' feelings would be different with the integration of technologies in assessment practices, their responses were quite similar and they both agreed that it would depend on the familiarity of the students with the assessment tools.

More specifically, one of the teachers mentioned that the stress would change in accordance to how familiar the students are with the specific tool and method of assessment. In the case where the students are not familiar with the tool and they do not know how to use it, or how the assessment will take place, their stress will increase. Especially if they have not used the technological tool during the school year, they will not feel comfortable and confident during the test and this is something that could have a negative influence on their performance. In contrast, students who are skilled in using the technologies, they would probably feel more comfortable and particularly confident in taking the test using technological tools and this confidence is likely to have a positive impact on their performance.

However, there are also those students who are not influenced by the methods or the tools they are going to use at their assessment activities, as soon as they can get the grade they want. Thus, from the teachers' perspective, there would be three different groups of students that would emerge from this integration. The first group would be more stressed because of the new tool and way of assessment that are not familiar with. The second group would be less stressed and more excited, since they would be familiar with technologies, and the third group of students who would not be affected by the mean of the assessment.

The students did not reply to a specific question about their feelings and performance in relation to technology and assessment, as it was deemed that they are quite abstract for their age. In contrast, they did refer to both performance and feelings through the activities of the interview.

The main outcome is that students familiarity with technologies varies widely. This variability is the main reason why there was a great variety of responses regarding the stress and performance with technologies in assessment. To be more specific, due to this diversity of opinions and skills, 4 different scenarios of how technologies could be integrated into assessment emerged (Table 10). Those scenarios were raised during the second activity (the role play), where the students had to become teachers themselves and think in which way they would assess their own students. Since, the students recognised the range of abilities regarding technologies in the classroom, the solutions that were given were quite aimed to fulfil the needs of all students.

Table 10. 4 different scenarios of uses emerged from the role play activity

4 different scenarios of uses emerged from the role play activity	Paper based Assessment (PbA)
	Technology based Assessment (TbA)
	Either TbA or PbA choice of the student
	Use of both TbA and PbA for different purposes (workings and final answers)

In the first case, students chose the paper test, as they said that this was the way they are used to take tests and it is a familiar procedure to them, which they can handle and they know how to work on it. In addition, they also know how the marking takes place and they feel more secure about it. On the second scenario students chose technological tools; computers, tablets or phones, as they wanted the test to be marked automatically, so they can have instant feedback on what they get right and what wrong.

In the third case, the students wanted to give the option to their classmates to choose the way they want to be assessed. The student participants recognised that some of their classmates are not very skilled on technologies and they believed that in this way, all students have the opportunity to succeed using the way they feel more comfortable. The fourth and last scenario included the combination of paper and technologies; computers or laptops. More specifically, students argued that the paper would be used for showing their workings, taking notes and writing down their thoughts, so they can organise their thinking easier, while the computer/laptop would be used for the final answers, as it gives them the opportunity to produce a neater and more organised piece of work.

Almost all students after discussion agreed that both means and ways; paper and technological tools, have their advantages and disadvantages and the best possible solution that would cover all the students would be to have both of them during the assessment activities. In addition, the affordances of the tools were also discussed during the interviews with the students mentioning practical issues in using technologies. For example, some of the students argued that they would not choose a test on a computer, where they have to type their answers on the keyboard, because they find the keyboard quite long and they confuse the location of the letters/keys. According to some students, using a mobile phone or a tablet would make typing easier, because they are quite smaller and they can see all the letters at once. Other students suggested that they would prefer to take a test on a computer, because it is plugged in and stable and there is no possibility of losing their test in case it run out of battery or it fall down. Last but not least, students also referred to the subjects they think would be more appropriate to be assessed using technologies and the subject that all the students mentioned was Maths, mainly because all of them had their maths homework on online.

3.9 Discussion

The research confirmed previous research concerning the integration of technologies in educational assessment, but it also offered new insights and understanding of their perceptions, which have not been reported in the literature.

3.9.1 Current use of Technologies in Educational Assessment in Primary School (teachers' and students' experiences)

Both schools that participated in the study were equipped with a variety of technological tools, such as whiteboards, computers, laptops, tablets and robots, and they use a variety of websites and software, like My Maths, Microsoft Office, Lego Mindstorms. However, these tools were mainly used for teaching purposes and the use of technology for assessment can be divided into two different categories.

The first category is summative assessment. The only use of technologies in relation to summative assessment is teachers' administrative work, and more specifically, the use of software to input the students' assessment data on the computers. In all the other cases, the summative practices are based on papers. This is explained due to the fact that educational assessment is highly accountable and controlled by the government, and the schools cannot decide on their own how they will run the end of the year tests (Mogey, 2011; Whitelock & Watt, 2008; Ripley, Tafler, Ridgway, Harding & Redif, 2009; Oldfield et al, 2012; Timmis et al 2012; Facer, 2012; Bevan, 2011). In UK primary schools, the students at Years 2 and 6 should take the national tests called SATs. More specifically, SATs are a series of educational assessments that are used to evaluate the performance and progress of students in the English primary schools. Those assessments combine teacher based and test based evaluations in order to produce a record for each student. Since those tests are all based on papers and the students should know how to take those specific type of exams, it would not be reasonable for the students to take tests using digital devices during the school year, and at the end of the year to take the paper tests.

The second category of assessment is formative assessment and in this case, the schools use a wide range of technologies and websites. The main use of technologies in formative assessment practices is the presentation of research and homework projects by the students. In some cases, the homework is set on a specific website on the Internet and students have to go online in order to do their homework. In addition, technologies are used for tracking students' real time progress and for the use of the Web, as a resource of information. It is evident that technology is integrated into assessment in the cases of ongoing every day assessment in the classroom, where there are no strict guidelines about the way that teachers can assess their students.

3.9.2 Teachers' perceptions about the use of Technologies in Educational Assessment

Teachers' thoughts about technologies in assessment were classified in terms of the advantages and challenges, suggestions and solutions, the reversal role of students and teachers and the school subjects' suitability for use of technologies in assessment.

Regarding the advantages, many of the aspects that were mentioned during the interviews confirm parts of the literature review. More specifically, the fact that technologies provide valuable instant feedback, improve the quality of their work, as well as the students' experience, decrease teachers' workload, offer assistance for SEN students and opportunities for students' self-assessment, are all factors that have been mentioned before by researchers in the field (Timmis et al. 2012; Jenkins, 2006; Broadfoot et al, 2014).

The teachers also referred to challenges that have been mentioned in previous research. More specifically, all teachers mentioned that educational assessment is highly accountable and controlled and this consists one of the biggest obstacles that prevent changes at schools (Mogey, 2011; Whitelock & Watt, 2008; Ripley et al. 2009). In addition, the issues of fear of technology and training, students' technological skills/familiarity with technology and practical issues are aspects that linked to technologies in education in general.

However, the aspect that most of the times is taken for granted in most of the research is the familiarity of the students with technology (Prensky, 2001). This could be explained by the fact that most of the research is mainly focused on secondary and higher education and by that age, the students are already considered quite familiar, not only with the technologies in general, but also with typing. Nevertheless, in the case of primary schools, the familiarity of the students with technologies should not be considered as given (Bennett, Maton & Kervin, 2008). Especially due to the age group of pupils who are between 6-11 years old, the range of their technological skills varies widely.

In addition, teachers seem not to trust technology, as they argued that using it for assessment purposes could be quite risky. The unpredictability of digital devices appears to be a concern for teachers, who argue that during an assessment activity, especially if it is a summative test, the activity should be organised as well as possible in order to avoid any unanticipated circumstances. Teachers seem to be sceptical and critical when they have to integrate technology in assessment practices (Bennett, Maton & Kervin, 2008), rather than *lazy* and *ineffective*, as Prensky (2001) has argued.

One of the basic key reasons why teachers do not use more ways of technologies in educational assessment is the lack of training and their own relationship with technologies (Bevan, 2011). According to the teachers, this is mainly a generational issue, which emerges due to the skills gap of the older teachers in comparison to the younger teachers who have had training with technologies. However, even the young teachers expressed some concerns regarding technologies and the way technological tools could be used in assessment, and they mentioned that they use only tools and software that they know they work and rarely the try new methods.

Thus, it could be argued that the issue of teachers' training is more complex and derives from the combination of their experiences and perceptions. Even if the young teachers have been trained to use technologies and they also use them on a daily basis outside of school, the integration of technologies into teaching is a quite complex and difficult process which requires specific guidance and training. It is not enough the teachers to be confident and familiar with the digital tools, but they should also be confident and certain about their teaching methods, because if something with technologies goes wrong, they should be flexible to change and adapt their method to the new situation quickly.

3.9.3 Students' perceptions about the use of Technologies in Educational Assessment

As far as primary students are concerned, no previous research has studied their perceptions regarding technologies in educational assessment. Most of the pupils' thoughts are linked to the general advantages and challenges of the area.

More specifically, and as it was recognised by their teachers as well, students argued that technologies improve their assessment experience, offer accessibility of homework from different places and assist their classmates with SEN, (Timmis et al, 2012; Jenkins, 2006; Broadfoot et al, 2014). Nevertheless, what was raised only by the student participants' perspective was the fact that technologies offer them the opportunity for a better quality of work. For example, a neater test, without squiggles or spelling mistakes. Students seemed to regard a neat piece of work quite highly, as they believe it adds to their grade. The appearance of a test, homework or project that will be assessed by the teacher seems to be of primary importance for the students.

In addition, one of the main benefits that students recognised in the use of technologies in educational assessment was the possibility of instant feedback. Pupils want fast, clear and adaptable feedback on their work in order to know their misconceptions and have the opportunity to address them quickly. In that way, if they have to do their homework online, they can practice many times, until they have everything correct, without having to wait the next day of the school, give the exercises to the teacher and wait for her feedback.

Regarding the challenges that pupils face in relation to technologies in educational assessment, students referred to some of the aspects that teachers mentioned, like their familiarity with technologies and their technological skills that vary widely in the classroom, but they also raised their own concerns on the issue. Students were quite worried about showing their workings to the teachers and the fact that the paper gives them the opportunity to organise their thoughts and take notes that will help them answer the questions, while when they have to take a test on the computer, they do not have the same opportunity. Especially because it is about assessment, the students wanted the teacher to have evidence of how they worked to solve a particular problem or exercise.

Students also expressed their concerns about challenges like cost and responsibility of using expensive devices. When they were asked if they use any kind of technologies for assessment purposes, all of them replied negatively, even if during the interviews they referred to the presentations they give and the software they use for their homework and projects. Thus, it is quite clear that for both students and teachers the word assessment is highly associated with summative and not formative practices. Especially for students, technologies are associated only with learning and not assessment.

However, the way that those perceptions are formed is, similarly to the teachers, quite complex and depend on many different factors, like the influence of their parents, teachers, peers, the society and their own experiences (Harris, 2015; Bennett & Maton, 2010). It was apparent in many of the students' responses that their thoughts were influenced and driven by the perceptions of their teachers or parents regarding technologies. For example, students mentioned that it is beneficial to have ICT lessons at school, but when you work many hours in front of a digital device, then this might affect your eyesight, or in the case of one student, assessment is quite important because it is used as an evaluation for the teachers as well. Thus, it should be noted that the perceptions of students in relation to technologies in assessment are highly influenced by their environment too and their origins are quite complex.

3.9.4 The ways that Technologies in Assessment influence students' feelings and performance

The study confirmed that student experience nervousness, anxiety, fear of failure and panic when it comes to assessment (Murphy et al. 2013). These feelings last for quite a long time. They start when the teachers announce the test and they finish only after they receive their grade. However, they all regard assessment highly and argue that it is an important part of their learning (ibid). The grade seems to be of primary importance for all students and it is also the main reason for their stress. As a result, students want to have the control and be aware and familiar with the ways they are going to be assessed, because otherwise, that would have a negative impact on their feelings and performance.

More specifically, students want to be able to choose the way they are going to be assessed, either it is on a digital device, or on paper. Most of them prefer to have both tools and make the best use of each mean. The computer would give a neat and flawless document, which they feel will be reflected positively in their grade, and the paper will assist them to organise their thoughts and keep a record of their workings. In addition, since their technological skills vary widely across the classroom, they want to be given the opportunity to choose the technology in order to use the one that they know they can perform better (Bennett, Maton & Kervin, 2008; Biggs, 2003).

Thus, the feelings and performance of students depend on whether the students are familiar with the assessment procedure and the tool they are going to use. If they feel confident and secure with the mean they choose, then they feel less stressed and perform better. If they do not know the method of assessment and are not familiar with the tool, then the stress will increase and their performance will be affected negatively. For instance, if through the whole school year the students are assessed on papers and at the end of the year the teacher introduces a new method with the use of a digital device, then the students will be more stressed and anxious about the whole assessment, because they are not familiar the method of assessment. The same would happen if the students were assessed on computers and the teacher would introduce paper tests.

The factor that affects the students the most is whether they are familiar with the assessment procedure they are going to use and the technology they are going to use.

It is of great interest that there is the belief, and that was also mentioned by some of the teachers, that if technologies are integrated into assessment practices, the feelings of the students will be more positive and they will be less stressed, because they have associated technologies with fun and entertainment. However, students perceptions indicate that there their feelings, stress and performance, are linked with the familiarity of the assessment procedure and not the means of it (Bennett, Maton & Kervin, 2008).

This was shown by the fact that during the first activity when students were asked which method of assessment they would choose they all chose the technological tool, but for the second activity they chose a mixture of two means of assessment in order to take advantage of both the paper and technologies. Thus, the integration of technologies in educational assessment could have a positive and a negative impact on students' feelings and performance depending on how familiar the students are with both the specific technologies and the assessment activity.

3.10 Conclusions

Technologies are used in educational assessment at primary schools in many different ways for formative assessment, but they are not used in summative tests and exams. The formative ways include power point presentations, online homework, and software for assessment data input. It is also notable that students, even if they are quite young (aged 8-11), they have strong opinions about assessment and they like suggesting different ways that they would prefer using technologies in their assessment.

Both teachers and students recognise what technologies can offer to assessment and what are the challenges that accompany such an integration. However, they are willing to try new ways of assessment activities, if they have clear evidence of success. The success of using technologies in educational assessment though depends on many different factors and especially on the relationship and familiarity that the students have with the assessment procedure and the tools.

4. Study 2

4.1 Introduction

Study 1 revealed that students are not as familiar with technologies as the literature suggests. There is a quite wide range of different attitudes and technological skills of students in the same classroom. Students' familiarity with ICT is one of the main factors that influences their attitudes and relationship towards technology in teaching and learning.

However, as mentioned in the theoretical frameworks, some researchers believe that there is a new generation of students who were raised with the use of technologies and due to their interaction with all the different kind of digital devices available, they are significantly different from the older generations, not only in terms of attitudes towards technologies and ways of learning, but also in the ways they process information. According to Jones and Shao (2011), the three most common concepts which describe this phenomenon are the *Net Generation* by Tapscott (1998, 2009), the *Digital Natives and Immigrants* by Prensky (2001) and the *Millennials* by Howe and Straus (2000), and Oblinger and Oblinger (2005) with the one by Prensky being the most cited one in academia (Judd, 2018; Koutropoulos, 2011). The main argument that all these terms have in common is the fact that students today are considered experts in the use of technology, because they were brought up surrounded and immersed in this technology.

However, the main argument against the digital native and digital immigrant's distinction is that it lacks empirical basis, is undertheorized and supported by anecdotes and appeals to common-sense beliefs (Bennett, Maton & Kevin, 2008). The claims regarding digital natives being a unique generation of experts in the use of technology are really strong, but there is little actual research based evidence supporting them. According to the opponents of digital natives, it is wrong to name a whole generation of people with one single name, because research shows that not all young people use technologies in the same way and one of the most important differentiated factors for that is the socioeconomic status of a person (Harris, 2015; Livingstone & Helsper, 2007; Aslanidou & Menexes, 2008). In addition to that, even when young people do have access to technologies that does not mean that they will be technologically empowered. The skills that students develop when they use technologies in their everyday life may not be directly applicable and transferable to academic tasks and sometimes students are even unhappy when the technologies they use at home for their entertainment become part of their studying (Bennett, Maton & Kervin, 2008).

In an educational context, teachers and schools have to cope with the differences and the diversity of the technological skills in their students. Educators should be aware and take into consideration the different types, attitudes, experiences and opportunities that the students have with technologies, in order to find the right ways of integrating ICT in teaching, learning and assessment. According to Kennedy et al. (2009) and Coombes (2009), the role of education is of primary importance in order that students become technologically empowered, because some of the young people might have confidence in using technologies, but limited understanding of how technologies work and how they can use them to learn.

Therefore, the second study of this thesis explored the phenomenon through a more nuanced and complex framework, which takes into consideration how children use technologies at home and how that relates to their use of online tools for maths homework. As Palfrey and Gasser (2011) argued, it is wrong to divide young and old people by their use of digital technologies, as different people at different ages have adapted technologies in different rates during their lives. There is no such generation of young people that all use technology in exactly the same ways. Instead of that, Palfrey and Gasser (2011) claim that there are some young people who use technologies in a more sophisticated way than other young people, but the whole generation is not using technology in the same sophisticated ways.

The main aim of study 2 was to explore the relationship between the variables of children's digital experiences, their use of the Online Maths Websites they use for their homework and their self-reported performance. The basic hypothesis was that the students who have more digital experiences at home will be more familiar with technologies and thus, they might perform better on the use of the online maths website and their online homework.

The first hypothesis aims to explore whether the age and school year of the children who took part in the questionnaire influence their digital experiences or not. As it was discussed in the second chapter and above, there is more evidence to oppose the findings of Prensky and his Digital Natives and Immigrants (2001) concept. Therefore, the first hypothesis is phrased based on the fact that children are not part of a unique generation of experts in the use of technologies, and that their digital experiences will change with the passage of the years.

- Hypothesis 1: There will be a positive relationship between the children's digital experiences and their school year and age.

- Hypothesis 2: There will be is a positive relationship between the children's digital experiences and their self-report use of Online Maths Websites for their homework

- Hypothesis 3: There will be a positive relationship between children's use of Online Maths Websites and their self-report performance on these websites

4.2 Method

4.2.1 Design

Study 2 focused on the relationship between the digital experiences of students and their use of Online Maths Websites (OMW). These websites are generally described as interactive online teaching and homework subscription websites, where students can find lessons paired with homework for practice and assessment across the Maths curriculum. Online websites are used at both home and school and one of the aims of the study was to identify if and how the different experiences that students have at school and home influence the students' use of technology and thus, their performance. Maths was the subject that both students and teachers considered as the most appropriate for using technologies in assessment and there is also an emerging interest by the Department of Education in the UK to try and find new ways to improve the teaching and learning of Maths in primary schools.

4.2.2 Participants

The study involved Key Stage 2 pupils from three different primary schools. The students were in Key Stage 2, aged between 7 to 11 years old. All the schools were based in Bath and North East Somerset in the UK and the schools were are all assessed by Ofsted as *Good* in 2012. All children participants were unpaid volunteers.

The study had a total number of 177 participants, with 66 boys and 110 girls (1 missing value) aged from 7 to 11 years old. All children who were in Key stage 2 of the schools could take part in the study if they wished to and there was no specific criterion that would exclude any of the children.

4.2.3 Materials and Measures

According to the existed literature, there were no previous validated questionnaires measuring the digital experiences of children and their use of online websites for homework. Most of the questionnaires that were relevant to the research's topic were addressed to parents (e.g. Valcke, Bonte, De Wever, & Rots, 2010) and not the children themselves. In addition, one of the main reasons that this study had to develop a new questionnaire was the fact that technologies are changing very fast. Thus, some of the questions about digital experiences of past questionnaires were considered outdated and irrelevant to how children interact nowadays.

The questionnaire consisted of two parts. The first part was related to the students' digital experiences at home and the second part was related to the way students use the online maths websites for their homework. The questionnaire design was informed by the findings of the first study, the literature related to students' digital experiences (Helsper & Eynon, 2010; Jones & Shao, 2011; Kennedy et al. 2009; Livingstone et al. 2014; Sorrentino, 2018), previous questionnaires in the field (Downey, Hayes & O'Neill, 2007; Livingstone, et al. 2011), the Educational Digital Divide model by Hohlfeld et al. (2008) and the Information and Communications Technology (ICT) curriculum of one of the schools.

The results from the first study indicated that children's familiarity with technology is one of the main factors that can influence the use of digital devices in assessment. Thus, it was considered important the questionnaire of this study to be able to capture children's familiarity with technology. The digital experiences and familiarity of children with technology were measured in terms of *access* to different kinds of technologies; computer, tablet, laptop, mobile phone and game console, the *frequency* that these technologies were used, the *breadth*/range of uses, the *confidence* on completing specific tasks and the self-reported level of students' *computer skills*.

The measure of access to digital devices was considered as one of the most important measures that would identify whether the concept of digital divide existed amongst the participants of the studies. The measure of *access* to technology included different digital devices, as it was important the children to report whether they had access to one or more technologies so that the study could capture a more accurate representation of their experiences.

The inclusion of the different digital devices was also important for the measure of *frequency,* which was an indicator of the length children were using the devices they had access to. Based on the Educational Digital Divide model, the access to technologies itself does not make a difference to children's technological skills, so it was considered essential the questionnaire to measure the *frequency* of use, as well as the *breadth* of use.

The *breadth* of use was also one of the most important measures of the questionnaire, as it is the measure that has been discussed in the literature of digital natives in depth and it has been suggested that it is the measure that future research should investigate (Helsper & Eynon, 2010; Jones & Shao, 2011; Sorrentino, 2018). The different options of the breadth of uses was based on the ICT curriculum of one of the schools who took part in the research. The ICT curriculum was used in order to specify what students are expected to know regarding the use of technologies at the level of Key Stage 2, explore whether they acquire the specific breadth of uses and whether they are confident on these uses.

The final two measures of children's digital experiences; *confidence* on the use of technology and *computer skills*, are also based on previous literature (Coombes, 2009; Kennedy et al. 2009; Livingstone et al. 2014). According to literature, children might be confident in the use of technologies for specific uses that are related to entertainment, but they do not acquire high level computer skills. Thus, the questionnaire aimed to capture the different uses that children are confident while using technology and explore the children's views on whether their computer skills are poor, good, very good, or excellent.

In the same way, and based on the literature review and the results of the first study, the use of the Online Maths Website was measured in terms of frequency of the homework done at home and school, the confidence in the use of the Website and the confidence in Maths itself, the help offered by a third person, the self-reported performance on the Maths Website, and an agreement scale of statements related to the use of the Website.

Due to the fact that the sample of the study consisted of children, the questions were designed carefully in terms of easy, clear and unambiguous language and a child friendly layout (Bell, 2007). More specifically, the questionnaire was designed to be as simple as possible, with short and straightforward questions, as according to Bell (2007), the key for a good questionnaire for children is simplicity. At the beginning of the questionnaire there was also a brief introductory text which aimed to inform children about the structure of the questionnaire and some important notes (Burgess, 2001; Borgers & Hox, 2000).

The questions were addressed directly and specifically to the children themselves to avoid de-personalised questions that make answers more difficult and complicated (Bell, 2007). The structure of the questions was kept the same throughout the questionnaire and, especially in the first part, all the questions for the different digital devices had exactly the same format in order to make it easier for the children to follow and answer the questions (ibid; Burgess, 2001). Due to the fact that children tend to have a limited memory capacity, even if they have been shown able to remember some of their experience in notable detail (Brainerd & Ornstein, 1991), all the retrospective questions were referring to the recent past and a concrete period of time (e.g. the last week). Almost all the questions were closed questions.

The options that the children had to choose for most of the questions were either Yes/No, or had three to four choices, as it is known that children under 11 years old get confused when more than 5 choices are given (Borgers & Hox, 2001; De Leeuw et al. 2002). The order of the questions and the responses was also taken into consideration in the design of the questionnaire. All the similar questions; for example those related to digital devices, or help from a third person, were put together. Children are also known to avoid reading a list of options from the top to the bottom and just choose the first option at the top of the list (Krosnich & Alwin, 1987), so the responses in this questionnaire were put next to each other, with a sufficient space between them and on the same line.

The scales were also designed based on the students' needs and were all completely-labelled (all the points had a specific label, or even a written and visual explanation) in order to raise the quality of the responses and ensure that the scales would be clear and easy to interpret by the children (Borgers et al, 2003; Bell, 2007; Scott, Brynin, & Smith, 1995). There were no negative, hypothetical or double barrelled questions involved, as they seem to be particularly problematic not only in the case of children participants, but also in general (Amato & Ochiltree, 1987; De Leeuw et al., 2004). All the images used in the questionnaire in terms of those next to the introductory text, those next to the question of each digital device, the labels in scales aimed to give the students two ways of receiving information related to the question, written and visual, in order to be sure what they are asked about. There were also more images at the beginning of the second part and the end of the questionnaire which aimed to add colour and a positive attitude towards the questionnaire. According to Scott, Brynin and Smith (1995), smiley faces and images in children's questionnaires add to the quality of the response.

In order to raise the validity of the children's responses and make sure that they are answering the questionnaire consciously, some of the questions were repeated in different ways and format. For example, the question regarding the children's confidence in the use of the online maths website, was also confirmed by their responses on the Agree-Disagree scale options; including statements like if they enjoy their online homework, if they find it easy and if they know how to use the online maths website. It has to be mentioned that all the responses of the questionnaires were self-reported statements of the children. The questionnaire was designed to last approximately 10-15 minutes.

4.2.3.1 Measures of Children's Digital Experiences

As discussed above, the digital experiences of the students were measured in terms of access to different kinds of technologies; computer, tablet, laptop, mobile phone and game console, the frequency that these technologies were used, the breadth/range of uses, the confidence on completing specific tasks and the self-reported level of students' computer skills. This section presents each measure of digital experience in more detail.

Access

The access to the 6 technological devices (listed below) was answered with a *Yes* or *No answer.*

- *i.* *Internet*
- *ii.* *Tablet*
- *iii.* *Game Console*
- *iv.* *Laptop*
- *v.* *Mobile Phone*
- *vi.* *Computer*

Frequency

The frequency with which children were using these devices was measured in 3 following sub questions if the child had answered positively to the question regarding the access to the specific digital device. The first 2 questions were related to the length children use the specific device in question during a weekday and during the weekend. Both questions could be answered on a 7 point scale (*0 = None, 15 = 15 minutes, 30 = 30 minutes, 60 = 1 hour, 120 = 2 hours, 180 = 3 hours, 240 = Over 3 hours*). The reliability of this measure was found to be acceptable (Cronbach's alpha=.616). The third sub question was asking children to answer how many times they used the device in question during the last week and they could answer it on a 4 point scale *(0 = None, 1 = Once a week, 2 = Several times a week, 3 = Every day*).

Breadth

The breadth of uses was measured with the following list of activities:

- i. *Chat online (talk with friends),*
- ii. *Play Games,*
- iii. *Surf the web for fun,*

iv. *Surf the web for Schoolwork/,*
v. *Search information,*
vi. *Go on YouTube,*
vii. *Do your Maths homework,*
viii. *Do other subjects' homework,*
ix. *Use the School's website,*
x. *Use Word, Create a video,*
xi. *Use Power Point, Listen to music,*
xii. *Do some coding,*
xiii. *Collaborate with classmates on a school project*.

The children could respond to each action saying how often they complete this activity on a 5 point scale (0 = *Never, 1 = Less than once a week, 2 = Once a week, 3 = Several times a week, 4 = Once a day, 5 = Several times a day*). The reliability of this measure was also found to be good (Cronbach's alpha=.743).

Confidence

The confidence that children have on the use of technology was measured with a list of actions based on their ICT curriculum and what they were expected to know at the primary school level. The list included the following activities

i. *Download files (e.g. Pictures, Games, Music, Videos, animation, text software),*
ii. *Save files in specific folders,*
iii. *Create folders,*
iv. *Type fast, Print,*
v. *Use the camera of the device,*
vi. *Be safe online,*
vii. *Use Word, Use*
viii. *Power Point,*
ix. *Copy and paste text,*
x. *Move files to different folders,*
xi. *Use a USB stick,*
xii. *Use text, photo,*
xiii. *sound and video editing tools,*

xiv. *Assess the information from the Internet,*

xv. *Share your ideas online,*

xvi. *Use the spellchecker.*

The children could respond to each action saying how confident they feel when they have to do each action on a 5 point scale (0 = *Not Confident, 1 = A bit confident, 2 = Not Sure, 3 = Confident, 4 = Very confident*). The reliability of this measure was found to be excellent (Cronbach's alpha=.928). The specific scale was also designed based on the students' needs and all the points of the scale had also a written and visual explanation as seen in the figure below.

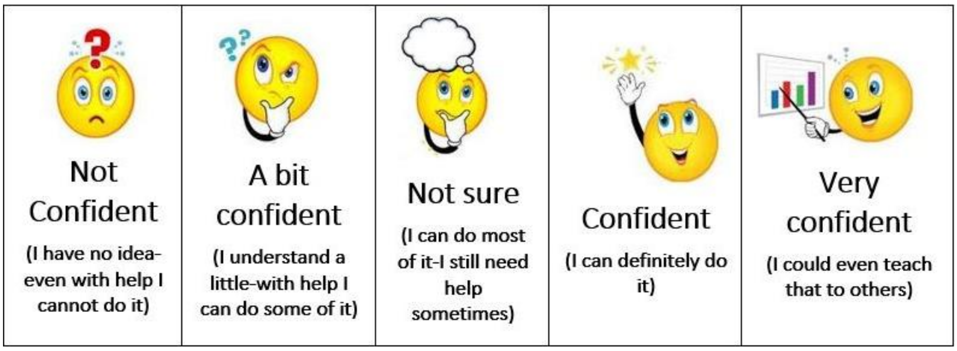

Figure 4 Visual and written explanations of the Likert confidence scale

Computer skills

Children's computer skills were measured using a 4 point scale (*1 = Poor, 2 = Good, 3 = Very Good, 4 = Excellent*). In order to raise the validity of the children's responses and make sure that they are answering the questionnaire consciously, some of the questions were repeated in different ways and formats. For example, the question regarding the children's computer skills, was also confirmed by their responses regarding if they have ever shown their parents how to use the computer/tablet/laptop and whether they usually need help from their teacher or classmates while working on the computer at school. Both questions used a 4 point scale (0 = Never, 1 = Sometimes, 2 = Quite Often, 3 = Always).

4.2.3.2 Measures of Children's Use of the Online Maths Website (Mathletics); 2nd part of the self-reported questionnaire

The use of the Online Maths Website, in this study's case Mathletics, was measured in terms of ***frequency*** of the homework carried out at home and school (*0 = Never, 1 = Sometimes, 2 = Quite Often, 3 = Always),* the time children spend on their online homework in a typical day (*0-10 minutes, 11-20 minutes, 21-30 minutes, 31-40 minutes, 41-50 minutes, 51-60 minutes, More than 1 hour, Other; with space to be filled*), the times they try each task (*1 = Once, 2 = Twice, 3 = Until I get the grade I want),* the ***confidence*** in the use of the Website and the confidence in Maths itself (*0 = Not Confident, 1 = A bit confident, 2 = Not sure, 3 = Confident, 4 = Very confident*), their ***performance*** in terms of the tasks they get right (1 = A few, 2 = Some, 3 = Many, 4 = All), and an agreement scale of statements related to the use of the Website (*I enjoy doing my Mathletics homework, I find the homework on Mathletics challenging, I enjoy maths more since using Mathletics, I know how to use Mathletics very well, I use paper and pen for my workings when I do my Mathletics homework online, I prefer to do My Maths homework in my notebook, I believe I can improve even more at Maths, I believe when I practice my Maths I become better, Everybody can improve their maths ability),* in a 5 point scale (*0 = Strongly disagree, 1 = Disagree, 2 = Not sure, 3 = Agree, 4 = Strongly agree)* in order to make sure the answers of confidence and performance were accurate. As with the confidence scale in part 1, the agreement scale included the following visual images together with the labels of the scale (Figure 5).

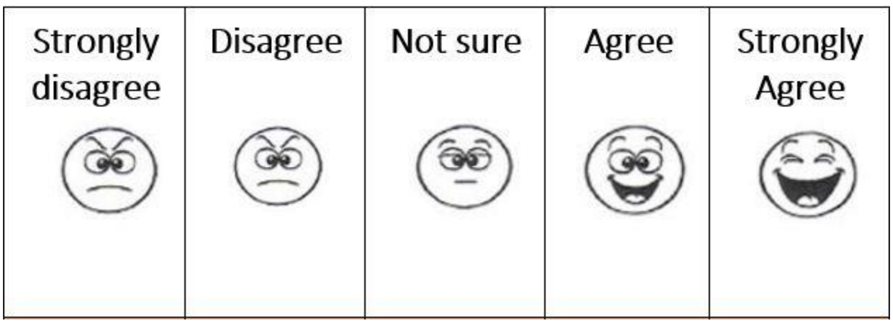

Figure 5 Visual explanations of the agreement scale

One of the most important parts of the design of a questionnaire for children is testing and pilot (Bell, 2007). However, there are also some pre-testing techniques and this study used the one which is to bring together researchers who have worked with children in the past and discuss the questions, suggest corrections and find the flaws of the questionnaires in order to improve it before the pilot and ensure the face validity of it (ibid). The questionnaire was piloted with two children of different ages who came to the lab and took the questionnaire in the presence of the researcher. After the pilot, the questions were slightly changed, mainly in terms of wording, and some new questions were added for clarification.

(The questionnaire can be seen in Appendix B.)

4.3 Ethics

The study was designed based on the ethical frameworks used by the University of Bath and the British Psychological Society (BPS) and received full ethical approval by the Ethics Committee of the University of Bath (Reference Number 15-246). In addition, due to the fact that the research was focused on the primary level of education and included young students, the study also followed the ethical guidelines for educational research by BERA (2011).

4.4 Procedure

The schools were contacted firstly through emails and then through personal communication with each school's Maths coordinators. It was agreed with the teachers and the Head of the schools, that the best way for data collection was the students to complete the questionnaire at home, during their free time and not during school hours. In this way, the students had the opportunity to answer all the questions at their own pace without the pressure of time. This procedure also supported by Bell (2007), Gray (2002) and Kail (1991), who suggest that children need more time to process the information from the questions and the option of completing the questionnaire at home without any time pressure, seemed to be the most appropriate way for the participants.

The researcher printed all the necessary materials in packs for each classroom and gave them to the schools. Each student from Years 3, 4, 5 and 6 from the 3 schools that took part in the study, received one plastic folder, which included two information sheets and consent forms, for parents and for students, and the questionnaire. The debrief sheets were given to the teachers who were asked to give one to each student when they brought the questionnaire back.

The first school received 228 plastic folders, the second 90 and the third 222. As it was stated on the information sheets, if the parents and students were happy with the aim of the study, they should both sign the consent forms, the student should complete the questionnaire and bring it back to the school together with the consent forms in the same plastic folder that it was given to them. Then, the teachers collected all the completed questionnaires over a period of 2 weeks and contacted the researcher to collect them from the school. At the end of the data collection, all the schools were informed that they would receive a brief report with the results of the study and that the researcher would always be available to talk to them or to their governors with more details about the findings.

4.5 Method of Data Analysis

The first step for the analysis was to code all the questions, enter the responses of the students from the questionnaire and check that all the data are transferred into the software correctly. The second step was to use the measures of children's digital experience, use of the online maths website and their performance, in order to test the hypotheses of the study.

The measures that were used for the analysis of the data had different subcategories. More specifically, the digital experiences of children were measured in terms of *Access, Frequency*, *Breadth, Confidence* and Level of *Computer skills*. It is worth mentioning here that the measures of access, frequency, breadth and confidence were summed up. For example, in order to find the total access to different kind of digital devices the *Access* would be computed as following: *Access* = Comp_access + Tablet_access + Laptop_access + Mobilephone_access + Gameconsole_access + Internet_access. The use of the OMW reported by children was measured in terms of *Frequency* that the website was used, *Confidence* on the website and *Performance* on it.

4.6 Results

This section presents the outcomes of the correlations between the measures of the digital experiences of children, their use of the OMW and their performance and the relationships that emerged during the analysis of the data. The analysis of the relationships between the measures of the study used the Spearman's rank correlation coefficient nonparametric measure, because most of the variables used in the study were ordinal.

4.6.1 Relationship between Children's Digital Experiences and their School Year and Age

The first hypothesis aims to explore whether the age and school year of the children who took part in the questionnaire influence their digital experiences or not.

Hypothesis 1: There will be a positive relationship between the children's digital experiences and their school year and age.

Table 11. Spearman's rho correlation between Digital Experience and the Age/School Year of the children

	School Year	Age
Access	.012	-.002
Frequency	.145	.106
Breadth	**.243****	**.203***
Confidence	**.517****	**.477****
Computer skills	.047	.058

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

According to Table 11, there are a few weak and moderate positive correlations between the measures of digital experiences and the School Years and Age that the children are. More specifically, it seems that the older children, in the upper primary school, use their digital devices for many different reasons (r=.243**, p<.01 and r=.203*, p<.05), and they are more confident in the use of technology in general (r=.517**, p<.01 and r=.477**, p<.01).

Thus, the first hypothesis of the study is accepted. It seems that both the age and school year do influence the children's digital experiences and the older children get, they use technologies for a variety of different reasons and the older they are the more confident they become on how to use their digital devices.

4.6.2 Relationship between the children's digital experiences and their self-report use of Mathletics for their homework

The second hypothesis of the study explores whether the children's digital experiences influence the way they use the Online Maths Website (OMW) when they do their online homework. It is expected that the more digital experiences the children have, the better they will be at using Mathletics for their homework.

Hypothesis 2: There will be a positive relationship between the children's digital experiences and their self-report use of Online Maths Websites for their homework

Table 12. Spearman correlation between Digital Experience, the OMW use and OMW performance

	Access	Frequency	Breadth	Confidence	Computer skills
OMW Frequency	-.029	**.162***	**.250****	.143	**.206****
OMW Confidence	-.090	-.055	.138	**.393****	**.361****

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 12 shows there is no significant correlation between the access to technologies and the use of the Online Maths Website (OMW). However, there is a significant small positive correlation between how often the children use technologies and how often they use the OMW ($r=.162^{*}$, $p<.05$), a medium positive correlation between the breadth of use of technologies and the frequency that the students use the OMW ($r=.250^{**}$, $p<.01$) and a medium positive correlation between how confident students are in the use of technologies and how confident they are in the use of the OMW ($r=.393^{**}$, $p<.01$). The children's computer skills are positively correlated to both the frequency that children use the OMW ($r=.206^{**}$, $p<.01$) and how confident they are in the use of the OMW ($r=.361^{**}$, $p<.01$).

Based on the results of the analysis, the second hypothesis is partially accepted, as there were a few statistically significant positive relationships between the children's digital experiences and their use of the Online Maths Websites. Thus, it could be argued that the way students use technologies at home in their everyday life does influence how they also use the OMW.

4.6.3 Relationship between children's self-report use of Mathletics and their self-report performance on the website

The third hypothesis investigates whether the way children use the Online Maths Websites influences their performance on them as well. It is expected that the better a child is in using the website, the better their performance is going to be as well.

Hypothesis 3: There will be a positive relationship between children's use of Online Maths Websites and their self-report performance on these websites

Analysis of the data revealed a small positive correlation between how confident the children are on the use of the OMW and the problems they get right ($r=.291^{**}$, $p<.01$), while the correlation between the OMW Frequency and OMW Performance ($r=.119$) is non-significant. Therefore, it seems that the more confident the students are on the OMW, the better their performance is.

Based on the results of the analysis, the third hypothesis is also partially accepted, as there is a statistically significant positive relationship between the confidence that the children use the OMW and their performance on it. Thus, it can be argued that the way students use the OMW does influence their performance on the OMW.

Following the second and third hypotheses it was considered interesting to explore what the exact uses are that influence the ways children use the Online Maths Website in terms of how often they use and how confident they feel on it.

Table 13. Spearman's rho correlation between OMW Frequency and specific uses of Breadth

	OMW Frequency
Chat online (talk with friends)	.107
Play Games	.109
Surf the web for fun	.047
Surf the web for Schoolwork/ Search information	**.252****
Go on YouTube	.141
Do your Maths homework	**.272****
Do other subjects' homework	**.156***
Use the School's website	**.208****
Use Word	**.181***
Create a video	**.304****
Use Power Point	.089
Listen to music	**.212****
Do some coding	.060
Collaborate with classmates on a school project	.130

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

According to the results, it seems that the frequency of the OMW is positively related to how often the students use the Internet for Schoolwork (r=.252**, p<0.01), do their Maths homework using digital devices (r=.272**, p<0.01), do other subjects' homework (r=.156*, p<0.05), use the School's website (r=.208**, p<0.01), use Word (r=.181*, p<0.01), create a video (r=.304**, p<0.01), and listen to music (r=.212**, p<0.01).

Due to the fact that the confidence the students have on the use of the OMW was related to the Breadth of uses, the different kind of uses included in the questionnaire were correlated to the OMW confidence.

Table 14. Spearman's rho correlation between OMW Confidence and specific uses of Breadth

	OMW Confidence
Chat online (talk with friends)	.101
Play Games	.022
Surf the web for fun	-.065
Surf the web for Schoolwork/ Search information	.114
Go on YouTube	.067
Do your Maths homework	.152
Do other subjects' homework	.039
Use the School's website	.015
Use Word	**.273****
Create a video	**.175***
Use Power Point	**.296****
Listen to music	.092
Do some coding	.006
Collaborate with classmates on a school project	.061

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

The results suggest that the use of Microsoft Word (r=.273**, p<0.01) and Power Point (r=.296**, p<0.01) are positively related to the confidence the students have on the OMW. In addition to that, but in a smaller extent, the confidence on the OMW is also related to how often they create videos (r=.175*, p<0.05).

Both Table 13 and Table 14 seem to suggest that children who use their digital devices for purposes related to schoolwork are the ones who are also using the OMW more often and are more confident on it. It is also worth mentioning that the when the same analysis run for the children's performance on the website, there were no significant correlations.

(The descriptive statistics of the study can be seen in Appendix E.)

4.7 Discussion

The results lead to some possible explanations in relation to the digital experiences of children, their use of the OMW and their performance. This section explores the findings of the study in relation to the existing literature.

Based on the results of the second study, it could be argued that this study does not hold evidence to support a digital divide among the students who took part in the research. More specifically and according to the descriptive statistics of access to the different kind of digital devices and the Internet, it seems that all children, except one, have access to the Internet and all of them have access to at least one digital device, e.g. either a computer, tablet, or laptop. This agrees with what Liabo, Simon and Nutt (2013) found in their review as well. Furthermore the findings suggest that the access to different kind of digital devices does not relate to the way children use technologies in line with Hargittai (2002) named as the *"second-level of digital divide*" (p.470), which moves away from just the access, to the use of technologies. Moreover, Liabo, Simon and Nutt (2013), mention that even if ICT is accessible in the UK, the issue is not whether it is used, but how it is used.

Liabo, Simon and Nutt (2013) argue that the digital experiences of children are linked to how often they use technologies and what they use them for, rather than if they have access to them. It seems that, the more often the children use technologies, the wider the breadth of uses is. This is also linked to their confidence, as the more often students use digital devices and the greater the range of uses is, the more confident they are on the use of technologies and the higher level of computer skills they have. Thus, both literature and the findings of the study suggest that the digital divide that exists today is linked to the use of digital devices and not the access to them.

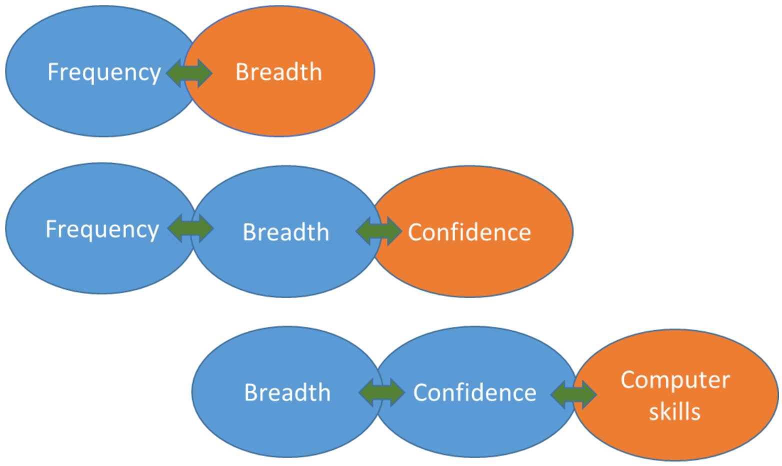

Figure 6 The relationships between the measures of digital experience

It is worth mentioning, that, as the Figure 6 shows above, the relationships between the measures of children's digital experiences are all linked in a shape of "*chain*", although it should be emphasized that there is no linear sequence between the variables. The fact that the arrows are pointing both ways illustrates the fact that the relationships are both ways. For example, it could be argued that the more the students use technologies the better computer skills they have, but it could also be argued that the better computer skills the children have, the more frequently they use technologies.

Regarding the relationships between the children's digital Experience, their OMW use and OMW performance, the results showed that the frequency of the OMW is linked to the frequency and breadth of the general use of digital devices and the level of children's computer skills (Figure 7). Thus, it could be argued that the more often and wider in breadth children use technologies and the better computer skills they have, the more frequently they would use the online Maths websites as well. This is also similar to the confidence the students have when they work on the OMW. Based on the results, it seems that the children who use technologies for many different

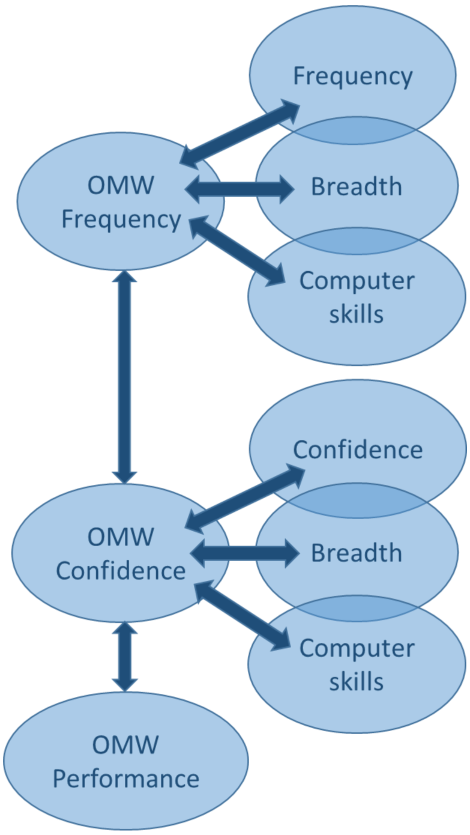

Figure 7 The relationships between the measures of Digital Experience, the use of the OMW and the performance on the OMWs

purposes and are confident and with good level of computer skills, they will also be confident on the use of the OMW.

The relationships between the performance of the OMW and the measures of the digital experience do not relate to each other. This means that how well students perform on the tasks and problems on the OMW is not linked to how they use digital devices in general.

However, what it was shown to link to the performance of the students on the OMW was the confidence they have on using the OMW and this confidence is also linked to the how often the children use the OMW. Therefore, it could be argued that the more often the students use the OMW, the more confident they are and the better their performance.

Due to the fact that the online websites are related to one specific subject; Maths, it was considered important to investigate the relationship between the confidence that students have in Maths and their use of the OMW and performance. According to the results, it is evident that the confidence students have in Maths is highly related to how confident they are in the use of the OMW and also, to how well they perform on it. Thus, it could be claimed that the better the students are in Maths, the more confident they will be on the use of the OMW and the better they will perform on the tasks and the problems.

Prensky's (2001) argues that all people who are born after 1980's are all considered experts in the use of technologies. Study 2 investigated the relationships between the digital experience of children, the OMW use and performance and the Age/School Year of the children. The findings show that there are moderate relationships between the range of uses of technologies and the confidence of children to their School Year and Age. More specifically, it seems that the older the students are, the greater the variation in their use of technologies is and the more confident they are. These findings contradict the idea that people who are born and raised with technologies are all fluent in the use of digital devices. The findings from study 2 show that children learn how to use technologies in different ways gaining confidence at the same time, year by year, as they get older and not since they were born. If Prensky's argument was valid, then there would be no relationship between the use of technologies and the age or the school year of the children

Given that both measures of the OMW use; the frequency and the confidence, were related to the breadth of uses, it was considered interesting to test the relationships between the specific uses of breadth that were included in the questionnaire and the frequency and confidence of the OMW. Regarding the frequency of use of the OMW, the results suggest that students who use technologies and use technologies and the Web for purposes related to their school are more possibly to use the OMW more frequently. More specifically, uses of technologies refer to online homework, use of Word and Power Point, creation of videos, searching of information.

In addition to that and regarding the relationship between the confidence on the OMW and the specific uses of breadth, the correlations were detected in relation to how often the children do their Maths homework online, use Word and Power Point. Therefore, it could be argued that, since all the relationships that exist between the use of the OMW and the breadth of uses are mainly related to schoolwork, the children who use the OMW more and are confident on it, are the students who are interested and conscious about their general schoolwork and performance.

4.8 Conclusions

The findings of this study support the wide diversity of children's technological skills and the fact that not all children are familiar with technologies and use them in the same patterns. The data suggest that even if children who are in primary schools now have grown up surrounded by different kinds of digital devices, their attitudes and ways of use of technologies differs to a great extent. The factors that are linked to the children's confidence on the use of technologies and higher level of computer skills are the frequency and the breadth of uses. The access to different kind of technologies does not seem to influence how often and the kind of interaction that children have with digital devices.

Furthermore, regarding the use of the Online Maths Websites (OMW), the results suggest that the frequency and the confidence of children are linked to their digital experiences, while their performance on the websites is not related to any measures of the digital experience. The children's performance is related to how confident they are on the use of the websites and also to their confidence on the subject of Maths.

Even if all the findings are based on children's self-reported data, it is of primary importance to give students the opportunity to talk about their digital experiences and how they use specific websites in terms of their formative, day to day assessment. The level of their technological skills and their attitudes towards digital technologies should not be taken as given. On the contrary, they should be investigated in depth and detail. For that purpose, and in order to gain a better understanding of the links between children's digital experiences and the use of online maths websites, it was considered important to get access to the usage data that are produced by the students' actions/tasks on the websites. As Jones (2012) has argued, combining self-reported data with usage data can offer a more complete understanding of the interaction that children have with technologies so teachers, educators and policy makers can modify their decisions accordingly.

5. Study 3

5.1 Introduction

Study 2 explored the children's perspective in relation to their digital experiences and the use of the OMW via self-report data, but there was no measure of the children's actual use of the OMW. In order to address this limitation, gain better understanding of the ways children use online maths websites in relation to their digital experiences, and provide stronger evidence to this thesis, study 3 was conducted in exactly the same way as Study 2 but this time it incorporated data of children's actual use of one of the OMW. The researcher formed a collaboration with 3P Learning, provider of Mathletics and gained access to the website's data archive. This allowed her to replicate the second study of the thesis, but with the addition of the usage data of children's use.

The aim of the study was to explore the relationship between children's digital experience, children' self-reported use of Mathletics and their actual use of Mathletics. The study tested the following hypotheses:

- Hypothesis 1: There will be a positive relationship between the children's digital experiences and their school year and age.
- Hypothesis 2: There will be a positive relationship between children's digital experiences and their self-reported use of Mathletics for their homework
- Hypothesis 3: There will be a positive relationship between children's use of Mathletics and their self-reported performance on Mathletics
- Hypothesis 4: There will be a positive relationship between children's digital experience and the actual usage data from Mathletics
- Hypothesis 5: There will be a positive relationship between the children's self-reported use of Mathletics and the actual usage data from Mathletics

5.2 Method

5.2.1 Design

This study used a correlational design to investigate the relationships between how children use digital technologies at home, how they report their use of the OMW for their homework and how they actually use the OMW based on usage data from

Mathletics. The variables included in the study were the digital experience of children, their self-reported use and performance using OMW and their actual performance and their actual use of the OMW. More specifically, study 3 is a replication of study 2, but with the difference that this time the self-reported data from the children were matched with the usage data of their use from the website. Therefore, the basic hypotheses for study 3 are the same as study 2, with the addition of the hypothesis regarding the matching of the data between the children's self-reported data and the usage data from the website.

5.2.2 Participants

The study involved Key Stage 2 pupils from a primary school in Bristol, which was assessed by Ofsted as *Outstanding* in 2012. All child participants were unpaid volunteers. There were 253 pupils (119 boys, 126 girls, 8 missing values) who took part in the study and they were all in Years 3-6 aged between 7 and 11 years old. All pupils who were in Key Stage 2 had the opportunity to take part in the study if they wished to. There was no specific criterion that would exclude any children from the study.

5.2.3 Measures and Materials

For the data collection, the study used paper questionnaires, which followed the same format and content as the questionnaire that was used in study 2. The questionnaire consisted of two parts. The first part was related to the students' digital experiences at home and the second part was related to the students' use of the online maths websites for their homework. The questionnaire was designed to last approximately 10-15 minutes. The only difference between the questionnaire for this study compared to study 2 was that this questionnaire was more focused on the use of Mathletics, rather than a general use of online maths websites and some extra questions which were added by Mathletics to assess whether the website had helped children with their Maths. As in study 2, at the beginning of the questionnaire there was a brief introductory text informing children about the structure of the questionnaire and some important notes (Burgess, 2001; Borgers & Hox, 2000), like the fact that all answers were private. Following this information, the children had to provide some basic information about themselves including their Mathletics username (this was used to identify the responses of children from the questionnaire and the usage data of use from the website), their school year and age and their gender. After this brief section, the first part of the questionnaire related to their digital experiences. Due to the fact that study 3 was a replication of study 2, the questionnaire followed exactly the same principles as the one used in study 2 in order for it to be child friendly.

(For more on the design of the questionnaire see Study 2, pages 115-118.)

5.2.3.1 Measures of Children's Digital Experiences

The digital experiences of the students were measured in terms of access to different kinds of technologies; computer, tablet, laptop, mobile phone, game console and electronic circuits, the frequency that these technologies were used, the breadth/range of uses, confidence in completing specific tasks and the self-reported level of students' computer skills. The extra digital device that was added in this questionnaire was the electronic circuit, which was considered a device that children could have owned in the last few years due to the sessions of coding they have at schools.

Access

The access to the 6 technological devices (listed below) was answered with a *Yes* or *No answer.*

- *vii.* *Internet*
- *viii.* *Tablet*
- *ix.* *Game Console*
- *x.* *Laptop*
- *xi.* *Mobile Phone*
- *xii.* *Computer*
- xiii. *Electronic Circuits (Arduino, Raspberry-pi, Makey-Makey, Micro:bit)*

The only question that included more options was the one related to the access to electronic devices, where the children could choose which of the following circuits they have access to at home; *Arduino, Raspberry Pi, Makey-Makey, Micro:bit, Other* (including an open space answer) and *None*.

Frequency, Breadth, Confidence and Computer skills

The measures used for the frequency, confidence and computer skills children have on digital devices were exactly the same as the ones used in the previous study (see Study 2 pages 119-121).

5.2.3.2 Measures of Children's Use of the Online Maths Website (Mathletics); 2nd part of the self-reported questionnaire

The use of the Online Maths Website, in this study's case Mathletics, was measured in terms of ***frequency*** of the homework carried out at home and school (*0 = Never, 1 = Sometimes, 2 = Quite Often, 3 = Always),* the time children spend on their online homework in a typical day (*0-10 minutes, 11-20 minutes, 21-30 minutes, 31-40 minutes, 41-50 minutes, 51-60 minutes, More than 1 hour, Other; with space to be filled*), the times they try each task (*1 = Once, 2 = Twice, 3 = Until I get the grade I want),* the ***confidence*** in the use of the Website and the confidence in Maths itself (*0 = Not Confident, 1 = A bit confident, 2 = Not sure, 3 = Confident, 4 = Very confident*), their ***performance*** in terms of the tasks they get right (1 = A few, 2 = Some, 3 = Many, 4 = All), and an agreement scale of statements related to the use of the Website (*I enjoy doing my Mathletics homework, I find the homework on Mathletics challenging, I enjoy maths more since using Mathletics, I know how to use Mathletics very well, I use paper and pen for my workings when I do my Mathletics homework online, I prefer to do My Maths homework in my notebook, I believe I can improve even more at Maths, I believe when I practice my Maths I become better, Everybody can improve their maths ability),* in a 5 point scale (*0 = Strongly disagree, 1 = Disagree, 2 = Not sure, 3 = Agree, 4 = Strongly agree)* in order to make sure the answers of confidence and performance were accurate. As with the confidence scale in part 1, the agreement scale included the following visual images together with the labels of the scale.

(The questionnaire can be seen in Appendix C.)

5.2.3.3 Children's usage data from the Online Maths Website (Mathletics data)

In addition to the self-reported data collected from the questionnaires, the researcher collected some of the children's usage data from the Online Maths Website, Mathletics. More specifically, the data came from the school's report, which is generated by Mathletics and includes data, statistics and graphs regarding how the website is used by the children and teachers. For the purposes of the study, the data taken from the report were the *username* of the children (which helped to match the data from the questionnaires to the data from the website), the individual *Activity Average Improvement* for each child (in percentage form), the *times* the children had *signed in* the website and the *time* children *spent online* in a period of a week, the average number of *Attempts* they usually take for each task, the *Number of Activities* they have completed, and the number of the *Activities* the children have *completed at school* and *at home*.

5.2.4 Ethics

The study was designed based on the ethical frameworks used by the University of Bath and the British Psychological Society (BPS) and all the relevant papers (e.g. information sheet, consent forms, debrief sheet) received full ethical approval by the Ethics Committee of the University of Bath (Reference Number 15-246). In addition, due to the fact that the research was focused on the primary level of education and included young students, the study also followed the ethical guidelines for educational research by BERA (2011).

5.2.5 Procedure

The researcher visited the school and gave 300 printed questionnaires in packs of 30 to the teachers of each class. The children completed the questionnaires on the same day at school and the researcher collected all filled in questionnaires after one hour, while being in the school in case any questions or queries came up from the children regarding the questionnaire. From the 300 questionnaires, the researcher collected 253 (84.3%), which was a high return rate. In addition to the questionnaire, data was also gathered from the website and the school's report produced by Mathletics for the period between 1st of August and 26th of March.

5.3 Method of Data Analysis

The analysis of the data took place in three different phases. The first phase included the analysis of the measures between the self-reported data given by the children, the second phase included the data collected from the website and the third phase included the matching of self-reported data to those from the website.

The first step for the analysis was to code all the questions, enter the responses of the students from the questionnaire and check that all the data are transferred into the software correctly. The second step was to use the measures of children's digital experience, use of the online maths website and their performance, in order to test the hypotheses of the study.

The measures that were used for the analysis of the data had different subcategories. More specifically, the digital experiences of children were measured in terms of *Access, Frequency*, *Breadth, Confidence* and Level of *Computer skills*. It is worth mentioning here that the measures of access, frequency, breadth and confidence were summed up. For example, in order to find the total access to different kind of digital devices the *Access* would be computed as following: *Access* = Comp_access + Tablet_access + Laptop_access + Mobilephone_access + Gameconsole_access + Circuit_access + Internet_access. The use of the OMW reported by children was measured in terms of *Frequency* that the website was used, *Confidence* on the website and *Performance* on it. The measures taken from the website were; *Activity Average Improvement, Sign-ins, Time online last week, Attempts, Number of Activities, Activities completed at school*, and *Activities completed at home.* The measures that were matched at the 3rd phase of the analysis were: *Activity Average Improvement* with *OMW Performance*, *Time online* with *Minutes spent online, Attempts* with *Times trying each task*, *Activities completed at school* with *Maths homework at school*, *Activities completed at home* with *Maths homework at home.*

5.4 Results

The section presents the results of the correlations between the measures of digital experiences, the use of the Online Maths Websites and the self-reported performance of the students and the data gathered from the archive of Mathletics. As in the previous study, the analysis of the relationships between the measures of the study used the Spearman's rank correlation coefficient nonparametric measure, because most of the variables used in the study were ordinal.

5.4.1 Relationship between Children's Digital Experiences and their School Year and Age

There is contradicting literature with some researchers suggesting that the school year and age of the children do not affect the ways they interact with technology (Prensky, 2001, 2011; Tapscott, 1998, 2009), while others arguing that the age is one of the factors that influence children's interaction with technologies (Bennett, Maton & Kevin, 2008). As was discussed, in the previous study, the hypothesis was phrased based on the existing evidence of the fact that children today cannot be considered digital natives based on their birth year. Table 15 examines whether the age and school year of the children is related to their digital experiences.

Hypothesis 1: There will be a positive relationship between the children's digital experiences and their school year and age.

Table 15. Spearman's rho correlation between Digital Experience and the Age/School Year of the children

	School Year	Age
Access	**.179****	**.197****
Frequency	**.309****	**.318****
Breadth	.094	.090
Confidence	**.395****	**.427****
Computer skills	-.096	-.027

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

According to Table 15, there are a few weak and moderate positive correlations between the measures of digital experiences and the School Years and Age that the children are. More specifically, it seems that the students in the upper primary school have more access to different kind of digital devices (r=.179**, p<.01 and r=.197**, p<.01), they use them more often (r=.309**, p<.01 and r=.318**, p<.01) and are more confident in the use of technology in general (r=.395**, p<.01 and r=.427**, p<.01).

Thus, it seems that both the age and school year influence the children's digital experiences and the older children get, the more they use technologies and the more confident they are with them and therefore, the hypothesis is accepted.

5.4.2 Relationship between children's digital experiences and their self-reported use of Mathletics for their homework

The first hypothesis of the study explores whether children's digital experiences influence the way they use the Online Maths Website (OMW), in this case Mathletics, when they do their online homework. It is expected that the more digital experiences the children have, the better they will be at using Mathletics for their homework.

Hypothesis 2: There will be a positive relationship between the children's digital experiences and their self-reported use of Mathletics for their homework.

Table 16. Spearman's rho correlation between Digital Experience, the OMW use and OMW performance

	Access	Frequency	Breadth	Confidence	Computer skills
OMW Frequency	-.108	-.059	.147	.052	.060
OMW Confidence	.029	.029	.045	**.215****	**.173****
OMW Performance	.018	.053	-.065	**.148***	**.146***

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 16 shows there are no significant correlations between the access, frequency and breadth that children use technologies and the use of the Online Maths Website (OMW). However, the OMW confidence is positively correlated to how confident students are when they use technologies in general (r=.215**, p<.01) and how good their computer skills are (r=.173**, p<.01). In relation to the children's performance on the OMW, this is positively linked to the same measures of digital experiences; confidence (r=.148*, p<.05) and the computer skills that children have (r=.146*, p<.05).

Based on the results of the analysis, the first hypothesis is partially accepted, as there were a few statistically significant positive relationships between the students' digital experiences, in terms of confidence and computer skills, and their use of the Online Maths Websites. Thus, it can be argued that the way students use technologies at home in their everyday life does influence how they also use the OMW.

5.4.3 Relationship between children's' self-reported use of Mathletics and their self-report performance on the website

The third hypothesis investigates whether the way children use the Online Maths Website influences their performance on it as well. It is expected that the better a child is in using the website, the better their performance is going to be.

Hypothesis 3: There will be a positive relationship between the use of the online website for Maths and their self-reported performance of students on the online Maths homework

The performance of students on the OMW is positively linked to their confidence using the OMW (r=.360**, p<.01), while there was no significant correlation between the OMW frequency and the OMW performance. Therefore, it seems that the more confident the students are on the OMW, the better their performance is.

Based on the results of the analysis, the third hypothesis is partially accepted, as there is a statistically significant positive relationship between the confidence that the children use the OMW and their performance on it. Thus, it can be argued that the way students use the OMW is partially linked to their performance on the OMW.

Breaking down the OMW use by the children, it was considered interesting to explore what the exact uses are that influence the ways children use the Online Maths Website in terms of how often they use and how confident they feel on it.

Table 17. Spearman's rho correlation between OMW Frequency and specific uses of Breadth

	OMW Frequency
Chat online (talk with friends).	-.056
Play Games	-.025
Surf the web for fun	.065
Surf the web for Schoolwork/ Search information	.021
Go on YouTube	-.094
Do your Maths homework	**.254****[**]
Do other subjects' homework	**.233**[**]
Use the School's website	**.173**[**]
Use Word	.057
Create a video	.016
Use Power Point	**.140***
Listen to music	-.005
Do some coding	.048
Collaborate with classmates on a school project	.012

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 17, reveals a few significant positive correlations between the frequency children use the OMW and uses such as doing their Maths homework (r=.254**, p<.01), doing other subjects' homework (r=.233**, p<.01), using the school's website (.173**, p<.01) and using the Power Point software (r=.140*, p<.05).

Table 18. Spearman's rho correlation between OMW Confidence and specific uses of Breadth

	OMW Confidence
Chat online (talk with friends)	-.002
Play Games	.085
Surf the web for fun	.033
Surf the web for Schoolwork/ Search information	.064
Go on YouTube	-.122
Do your Maths homework	**.190****
Do other subjects' homework	**.258****
Use the School's website	.047
Use Word	-.028
Create a video	-.003
Use Power Point	**.135***
Listen to music	-.006
Do some coding	.059
Collaborate with classmates on a school project	.062

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 18 shows very similar significant positive correlations between how confident children are on the use of the OMW and breadth of use. More specifically, OMW confidence is linked positively to uses such as doing Maths homework ($r=.190^{**}$, $p<.01$), doing other subjects' homework ($r=.258^{**}$, $p<.01$) and using the Power Point software ($r=.135^{*}$, $p<.05$).

Both Table 17 and Table 18 seem to suggest that children who use their digital devices for purposes related to schoolwork are the ones who are also using the OMW more often and are more confident on it. It is also worth mentioning that the when the same analysis was run for the children's' performance on the website, there were no significant correlations.

5.4.4 Relationship between children's digital experience and the usage data from Mathletics

The fourth hypothesis of the study explores the relationships between the self-reported data from children based on the questionnaires and the actual usage data gathered from the archive of Mathletics. More specifically, it explores whether the digital experiences of children are linked to the way they use Mathletics. It is expected that the more digital experiences children have the more they will be using the website as well.

Hypothesis 4: There will be a positive relationship between children's digital experience and the actual usage data from Mathletics

Table 19. Spearman's rho correlation between the Digital Experiences of children and the data from Mathletics

	Digital Experience				
Usage Data from Mathletics	Access	Frequency	Breadth	Confidence	Computer Skills
Usage Performance					
Average Improvement	.091	**.181***	.051	**.152***	.059
Usage Frequency					
Sign-ins	**-.133***	**-.142***	-.006	-.098	.108
Time online last week	**-.133***	**-.137***	-.021	-.134	.071
Attempts	-.060	**-.245****	-.070	**-.158***	-.052
Number of Activities	**-.180****	**-.221****	-.128	**-.187****	-.009
Activities completed at school	-.106	-.008	.074	.052	**.205****
Activities completed at home	**-.147***	**-.250****	-.116	**-.217****	-.084

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

According to Table 19, it seems that the average improvement of the children is positively correlated to the frequency children use technologies (r=.181*, $p<.05$) and the confidence they have in the use of technologies (r=.152*, $p<.05$). This might mean that the more frequently children use digital devices at home and the more confident they are in the use of technologies, the more chances they have to improve their Mathletics performance. However, the negative correlations that exist between the measures of digital experience and the data collected from Mathletics regarding how children use the website were not expected. Especially the negative correlations between the access to different kind of digital devices that children have and how many times they sign in (r=-.133*, p<.05), the time they spend online (r=-.133*, p<.05), the number of activities they complete (r=-.180**, p<.01) and the activities they complete at home (r=-.147*, p<.05). All these relationships were expected to be in the opposite direction. The same unexpected results were found regarding how frequently children say they use Mathletics and how many attempts they usually try (r=-.245**, p<.01), the number of activities they complete (r=-.221**, p<.01) and the activities they do at home (r=-.250**, p<.01). It was expected that the more frequently children used technologies, the more attempts and activities they would complete at home. However, the results showed the opposite. The confidence that children have with the use of technologies was also negatively related to how many attempts they try for each task (r=-.158*, p<.05), the number of activities they complete (r=-.217**, p<.01) and the activities they complete at home (r=-.187**, p<.01). This could mean that the more confident children make less attempts and complete a smaller number of activities on the website. On the other hand, the only positive correlation amongst one of the measures of digital experiences and the Mathletics usage frequency was found between the children's computer skills and the activities they complete at school (r=.205**, p<.01). It could be argued that students with better computer skills tend to complete more online maths activities at school.

Thus, it could be argued that there are a few links between the digital experiences of children and the way they use the online maths website, but there is no clear direction to whether this links between the two is positive or negative. This means that the hypothesis is neither accepted nor rejected.

Following the fourth hypothesis, it was considered interesting to explore what data of usage influence the self-reported frequency, confidence and performance of the children on Mathletics. There were no relationships between the frequency children use the website and their usage data. However, there were a few small positive correlations between the confidence and performance that the children reported they have on Mathletics and their usage data of usage.

Table 20. Spearman's rho correlation between OMW Confidence and data of usage

	OMW Confidence
Average Improvement	.125
Sign-ins	**.143***
Time online last week	**.131***
Attempts	**.212****
Number of Activities	**.153***
Activities completed at school	-.068
Activities completed at home	**.272****

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

According to Table 20, it seems that the confidence that the children reported having on Mathletics is positively related to how many times they sign in (r=-.143*, p<.05), how long they spend on the website (r=-.131*, p<.05), the number of attempts they take for each activity (r=-.212**, p<.01), the number of activities they try (r=-.153*, p<.05) and the activities they complete at home (r=-.272**, p<.01).

Table 21. Spearman's rho correlation between OMW Performance and data of usage

	OMW Performance
Average Improvement	.102
Sign-ins	**.138***
Time online last week	**.164****
Attempts	.087
Number of Activities	**.154***
Activities completed at school	-.094
Activities completed at home	**.161***

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 21 shows that the performance that children reported is positively related to how many times they sign in on the website (r=.138*, p<.05), the time they spend online (r=.164**, p<.01), the number of activities they complete (r=.154*, p<.05) and the activities they complete at home (r=.161*, p<.05.)

Both tables suggest that the children who sign in more times on Mathletics, spend time on it and complete a high number of activities, mainly at home, they have more confidence on using the website and they report better performance on it.

5.4.5 Relationship between self-reported data from the children and the actual usage data from Mathletics

The fifth and last hypothesis examines whether the self-reported data given by the children matches the data gathered by the archive of Mathletics. More specifically, some of the questions were directly related to some of the data from the website's online archive. The questions included aspects such as the children's performance and their actual scores, the time they spend on the maths website, the attempts they usually take for each activity they complete and the place they do their online homework; at home or at school. It is expected that what the children reported in the questionnaires will match what they actually did on the website.

Hypothesis 5: There will be a positive relationship between the children's self-reported use of Mathletics and the actual usage data from Mathletics

Table 22. Spearman's rho correlation between the self-reported data from the questionnaires and the usage data of use from Mathletics

Usage data from the website	Self-reported data	Spearman's rho correlation
Activity Average Improvement	OMW Performance	.102
Time online	Minutes spent online	**.170****
Attempts	Times trying each task	**.385****
Activities completed at school	Maths homework at school	**.299****
Activities completed at home	Maths homework at home	**.190****

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 22 shows that four out of the five common measures from the questionnaires and the data from Mathletics are correlated positively. The fact that the self-reported data given by the children are positively correlated with the usage data taken from the archive of Mathletics means that what children reported in the questionnaire matches what they actually did on the website, but to an extent. The measures that were positively linked were the self-reported and actual time the children spend on the website ($r=.170^{**}$, $p<.01$ with 2.89% of the variance explained), the attempts they take for each task ($r=.385^{**}$, $p<.01$ with 14.82% of the variance explained), the activities they complete at school ($r=.299^{**}$, $p<.01$ with 8.94% of the variance explained) and the activities completed at home ($r=.190^{**}$, $p<.01$ with 3.61% of the variance explained), while the only measures of self-reported and usage data that were not linked to each other was the performance on the website.

Based on Table 22 and the fact that there are a few significant positive correlations between the data given by children and the data gathered from the website, the fifth hypothesis is partially accepted. It could be argued that, although the children could be considered quite young to report their own usage of a website, what they report is related to reality.

(The descriptive statistics of the study can be seen in Appendix E.)

5.5 Discussion

The aim of the study was to explore the relationship between children's digital experience, children' self-reported use of Mathletics and their actual use of Mathletics. The study found that both the age and school year influences children's digital experiences and the older children get, the more they use technologies and the more confident they become with them, which counters the arguments concerning Digital Natives (Prensky, 2001).

In addition, there are positive relationships between the children's digital experiences, in terms of confidence and computer skills, and their use of the Online Maths Websites, mainly in terms of the confidence and the performance children have on the OMW, which suggests that the way children use technologies at home in their everyday life does influence how they also use the OMW. Similarly, the way children use the Online

Maths Website also affects their performance, mainly in terms of how confident they are while using the website. Further investigation and analysis on the children's use of Mathletics showed that the children who tend to use their digital devices for purposes related to schoolwork, are the ones who are also using the OMW more often and are more confident on it. This is also supported by Kim et al. (2018) who argued that children who used the computer for schoolwork frequently revealed a high mathematics self-efficacy which resulted in higher mathematics performance.

The analysis of the usage data from Mathletics, showed that there was one positive link between how often children use technologies and how well they perform on the website, but there were also a few negative links that were not expected. Thus, it could be argued that children's digital experiences and their usage of the website are linked, but there is no clear direction to whether the links between the two is positive or negative. The only similarity between the self-reported data and the usage data from the website is the confidence of the children on the use of technologies is linked positively to both their self-reported data and the usage data from the website. It is worth mentioning that the link is not strong, but it is significant.

The results lead to some possible explanations in relation to the digital experiences of children, their use of the OMW and their performance. The following sub-sections explore the findings of the study in relation to the existing literature.

5.5.1 Self-reported data given by children

According to the findings of study 3, it seems that almost all children (98.4%) have access to the internet and all of them have access to at least one digital device at home, which agrees with the findings of the previous study and also the review by Liabo, Simo and Nutt (2013). However, something that contradicts the results of study 2 and the concept of the *second-level of digital divide*, which moves away from just the access to technologies to the use of them (Liabo, Simon & Nutt, 2013), is the fact that in this study, access was positively linked to all the other measures of digital experiences; the frequency, breadth, confidence and computer skills that children have. This means that the access to different kind of digital devices does have an impact on how the children use these devices, how confident they are using them and the level of computer skills they develop while using them. So this finding could possibly support the concept of the digital divide and the fact that there is a gap between those who have access to ICT and those who do not and that might affect how they use technology (Swain & Pearson, 2001; Kalyanpur & Krimani, 2005; Carvin, 2000; Blau, 2002). The same positive links were observed with all the measures of digital experiences and that suggests that all measures are connected and related to each other in a positive way. In other words, the more access to different kinds of technologies children have, the more often they use them, the wider the range of use, the more confident the children are and the better computer skills they have. Thus, the relationships between the measures of children's digital experiences appear to be like a chain, where each measure is related to the others in a positive way (Figure 8). The fact that the arrows are pointing both ways illustrates the fact that the relationships are both ways. For example, it could be argued that the more the students use technologies the better computer skills they have, but it could also be argued that the better computer skills the children have, the more frequently they use technologies.

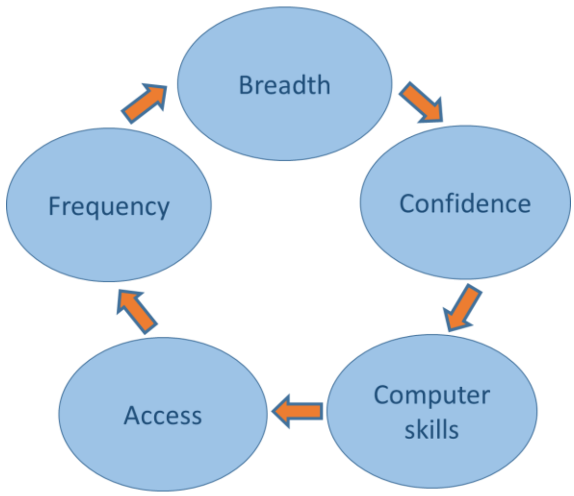

Figure 8 Relationships between the measures of children's digital experiences

In addition to that, the positive relationships that were found between the measures of digital experience, the use of the website and the performance of the pupils on the website show that the confidence and level of computer skills children have based on their digital experiences influence their confidence on the website and their performance. In other words, it could be argued that the more confident children are in using different kind of digital devices and the better computer skills they have, the more confident they are on the use of the online maths website and the better their performance is as well. Moreover, the confidence that children have while using the website is also linked positively to their performance on the website. Thus, the confidence that children have while using the website affects their performance on it too.

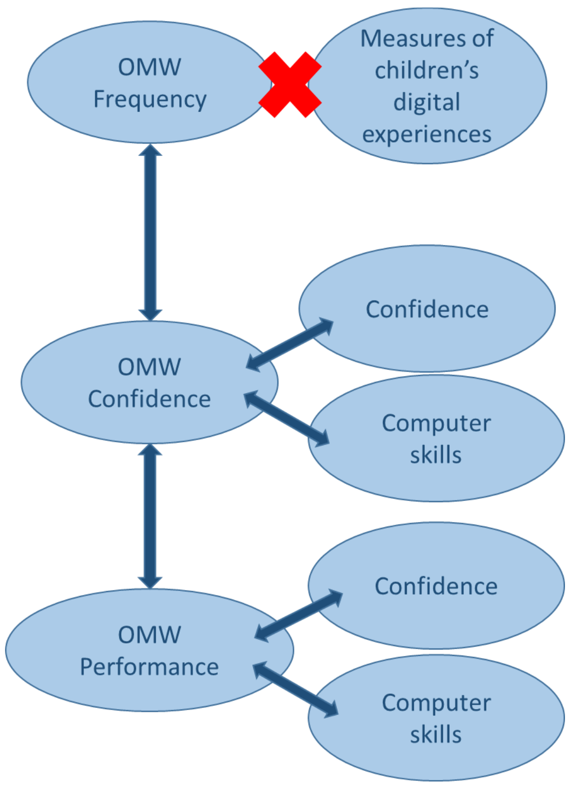

Figure 9 Relationships between the measures of children's digital experiences and the measures of the Online Maths Website use

Based on Figure 9, it could be argued that even if the frequency that children use the OMW does not link to their digital experiences, the children's confidence and computer skills on the use of general technology do influence how confident pupils are on the use of the OMW and how well they perform. Part of these findings are in agreement with the findings from study 2, where the confidence that the children have on the OMW was linked to their confidence and computer skills in the general use of technologies.

However, it is worth mentioning that something else that was also linked to children's performance on the online maths website and is not strictly relevant to their digital experiences is the confidence that children have in the subject of Maths. According to the results from both studies 2 and 3, the more confident children are in Maths, the better their performance on the website is. Thus, it is evident that there are other variables that influence the pupils' performance on the website together with their digital experiences.

5.5.2 Data gathered from the Online Maths Website

Based on the findings, 196 pupils out of the 253 had a change in their performance while using the website with a significant number of them showing an improvement in performance (77.47%). According to the relationships between the variables of data collected from the website and the digital experiences of children, it seems that what influences the performance of the pupils on the website is the frequency that the children use the different kind of digital devices at home. It could be argued that the more often the children use technologies at home, the better their performance on the online maths website is. However, some of the findings regarding the digital experiences of children and their use of the website were not as hypothesised. More specifically, there were a few negative correlations between the measures of digital experience and the measures of use taken from the website.

Regarding the self-reported data on the use of the website and the data gathered from the website, the results showed that there were no links between how often, how confident and how well the children mentioned they performed on the website with their actual performance on the website. Nevertheless, when it comes to the measures of the actual use of the website, it seems that the confidence the children have while using the website and their self-reported performance are both linked positively to how children use the website. This could mean that the more confident children are on the use of the website and the better their self-reported performance is, the more they are using the website.

5.5.3 Matching the self-reported data with the data from website

As part of the analysis of the data, the study explored the relationships between the self-reported data given by the children and the usage data of use taken from the website. The results showed that four out of five measures were matched positively and that means that children are able to offer valid data regarding what they are doing on the online maths website. This finding also suggests that children can be trusted and their opinions should be taken into account. However, it is worth mentioning that the correlations were small and thus, the relationships were not strong.

5.5.4 The role of the school year and age of the children in relation to the use of the Online Maths Website (OMW)

Based on the literature and the previous findings from study 2 relationships between the measures of children's digital experiences and their school year, age and gender were explored. Results showed that there were a few positive relations between the school year, age and the measures of access, frequency and confidence. This suggests that the older children are, the more access they have to different kind of technologies, the more often they use these technologies and the more confident they are with them. The findings from study 3 confirm the findings from study 2, but disagree with the concept of digital natives.

5.6 Conclusions

Most of the findings in this study confirmed the findings of study 2 and showed that there are links between how children use different kind of digital devices at home, how they use online maths websites and how they perform on these websites. One of the main differences between the two very similar studies was that the access to technology did not link to any other measures of digital experiences of the previous study supporting the concept of the "second-level of digital divide" (Liabo, Simon & Nutt, 2013), while in the current study the access to technology was linked positively to all the other measures of children's digital experiences which seems to support the original concept of the digital divide (Swain & Pearson, 2001; Kalyanpur & Krimani, 2005; Carvin, 2000; Blau, 2002).

In terms of the links between the digital experiences of children and their use and performance on the website, the findings suggest that the confidence and level of computer skills children have influence positively their confidence and performance on the online maths website, in this case Mathletics. It seems that the more confident children are using Mathletics, the better their performance on the website is. In addition to that, results showed that most children's performance improved after using the website and part of that improvement was related to how often children were using digital technologies at home.

The fact that the current study collected data from the website and analysed it together with the self-reported data given by the children is considered as one of the most important strengths of this research, as it offers both the perspective of the children and also an insight into the children's usage of the website. It is also worth mentioning that the positive links that were found after the matching of these two sets of data offers evidence that children can be trusted in their self-report.

The findings of this study can help teachers to understand better, how their pupils are using online maths websites for their homework and how they can help them in order to gain more confidence and improve their performance on these Online Maths Websites. It is of primary importance for teachers to be aware of the different levels of technological skills that the children have and try to help them in different ways in order to gain the most out of the use of online maths websites. In addition to that, online maths websites like Mathletics could also benefit from the results of the study by examining how the use of the website influences the children's performance. Teachers can identify which measures of children's digital experiences are the ones that are linked to the online maths performance of their students (frequency of using technologies and confidence on the use of technologies) and develop ways that could assist children improve their maths scores.

Based on the fact that the performance of the children is directly related to the way the online maths websites are used by the teachers, the final study of the thesis explored the relationships between the digital experiences of teachers and the ways they use the OMW for children's homework. Having both sides of teachers' and children's digital experiences and uses of OMW offers a better understanding of how children and teachers use digital devices at home and school. The investigation of the teachers' digital experiences was particularly interesting and important, as both theoretical frameworks that are explored in this thesis; Digital Native and Immigrants and the alternative model, which includes Vygotsky, discuss the role of teachers in relation to pupils' technology use and learning respectively.

6. Study 4

6.1 Introduction

Study 1 revealed how teachers and pupils perceive the use of technologies in educational assessment in primary schools and what their current experiences are. Both teachers and pupils shared some thoughts, ideas and challenges towards the use of technologies in educational assessment. Some of the common themes included pupils' and teachers' digital experiences at home and their technological skills/familiarity with technology. Following up the findings from the first study, study 2 and study 3 investigated the relationship between the digital experiences of pupils and their use and performance on Online Maths Websites (OMW). In the same way, and in order to get a more complete idea of the same issues for the teachers, the fourth study investigated the relationship between the digital experiences of teachers and their use of OMWs. In addition, study four explored the teachers' training on how to use these kinds of online websites, which was one of the main themes that came up during teachers' interviews in study 1 and some of them referred to it as a generational issue and an extra skill they have to learn on their own.

The fact that the familiarity of teachers with ICT was characterised as a generational issue amongst the older and younger teachers by the teacher participants in study one, illustrates a possible distinction in the same way that Digital Natives and Immigrants (Prensky, 2001), Net Generation (Tapscott, 2009, 1998; Oblinger & Oblinger, 2005) and Millennials (Howe & Strauss, 2000) have described before. The advocates of these concepts argue that digital immigrant teachers – based on their age (born before 1980), face difficulties teaching their digital native students who are fundamentally different from previous generations of students. They suggest that teachers should learn how to use technologies in similar ways to their students in order to be able to respond to their students' needs. However, due to the fact that the differences between the two groups; digital native students and digital immigrant teachers, are so significant, they claim that the teachers, no matter how hard they will try, they will not be able to close the gap between them and their students. They argue that one of the solutions for this would be the entrance of digital natives in education and more specifically their transition from being digital native students to becoming digital native teachers – based on their age (born after 1980). The argument is based on the fact that when digital natives become teachers, they will be able to use all their technological knowledge and skills in their teaching in order to make it interesting and suitable for their own digital native students. When Prensky developed his concept of Digital Natives and Immigrants back in 2001, the digital native students he referred to were just finishing high school and they were entering higher education. That meant that all the teachers working in education were part of the Digital Immigrant generation. However, today the situation is different and the teachers who work in schools are coming from both generations of natives and immigrants.

As with the rest of the arguments Prensky (2001), Tapscott, (2009; 1998), Oblinger and Oblinger (2005), and Howe and Strauss (2000) support, the specific solution is over simplistic, underestimates the complexity of the issue and is not supported by research-based evidence (Bayne & Ross, 2007). However, the interesting part of this specific argument is that, although there is no research-based evidence to support the success of this solution, there is also no research-based evidence against it. Most of the research and the critiques of Prensky's (2001) concept have focused on digital natives as the students, but there is very little research conducted on the generational differences amongst teachers, who now include both digital natives and immigrants. One such example is the study conducted by Lei (2009) which found that digital native pre-service teachers reported being positive towards technology, but not very confident in using it, as they acquired basic technological skills and knew how to use ICT for social communications purposes, but they lacked experience on how to use technology in their teaching and classrooms.

Guo, Dobson and Petrina (2008) examined the relationship between age and ICT competency amongst pre-service teachers and they found that there was not a statistically significant difference between age and ICT skills, which means that the digital native teachers did not differ from digital immigrant teachers in terms of their ICT scores. However, in a more recent study, Yurdakul (2018) explored the relationship between the Technological Pedagogical Content Knowledge (TPACK) proficiency and the digital nativity of pre-service teachers and he found that a high level of digital nativity could predict a high level of TPACK proficiency. This could mean that the ways pre-service teachers use technologies in their everyday lives could influence the ways they use technologies at schools. Although the research was conducted in Turkey and the results cannot be generalised in the UK, these findings add to the literature that suggests that today's pre-service teachers can be considered digital natives.

In relation to teachers in-service, there is only a very limited amount of papers that have conducted research on the differences between digital native and immigrant teachers, and most of them are focusing either on high school or on higher education. An example of such research is the study conducted by Johnson (2018) who investigated the differences in the use of technology between digital native and immigrant faculty members at the University of Alabama. She found that there were no significant differences in the ways the two groups were using technology, apart from one specific area. It was found that digital immigrant faculty members were using online resources in their classrooms more often than their digital native colleagues were. This is one of the few studies that supports a difference between digital native and immigrant teachers with the immigrant teachers using an aspect of technology more than the digital native teachers do. However, Howlett and Waemusa (2018) investigated the differences in the use of ICT between high school digital native and immigrant teachers in Thailand and they found that digital native teachers had higher scores in terms of how often they use technology, their level of computer skills and their confidence on the use of technologies.

In relation to the use of technologies and mathematics by teachers in primary schools, Remillard, Steenbrugge, Machalow, Koljonen, Hemmi and Krzywacki, (2018) conducted research on how elementary teachers use digital instructional resources in maths lessons in primary schools. They found that the main reasons that the teachers used ICT in their maths lessons were to a) improve whole-class instruction by supplementing their printed materials and giving the chance to children to interact and share their work with their classmates, b) structure students' work by giving them specific tasks that they could work on in groups, individually or for homework that are engaging, personalised easy to assess, and c) improve and inform their own professional skills. These reasons agree with the themes that were discussed in study 1 and are part of the investigation of the current study.

Orlando and Attard (2016) explored the ways that early career primary school teachers use technologies in their teaching of maths. They argued, that while there is an anticipation and expectation that young teachers, who can be considered Digital Natives, are more capable and motivated to use technologies in their teaching than the Digital Immigrant teachers are, there is currently not enough research-based evidence to support that. There is still no clear answer to whether the ways teachers use technologies in their everyday life have an influence on how they use technologies in teaching maths. Therefore, they suggest that it is necessary for the teachers, Natives and Immigrants, to have a support and training on how to use ICT for teaching maths.

It is evident that the existing research in relation to Digital Native and Immigrant teachers have focused mainly on pre-service teachers and teachers that work in high schools and higher education, but there is a gap in knowledge in relation to what are the differences between Digital Native and Immigrant teachers in primary schools. Study 4 focuses on the relationship between the digital experiences of teachers and their use of OMWs and whether digital immigrant teachers are different from the digital native teachers in terms of their technological skills, use of OMWs and training.

The study examined the following hypotheses:

- Hypothesis 1: There will be differences between the measures of digital experiences, use of OMW and training between the digital native and immigrant teachers.
- Hypothesis 2: There will be a positive relationship between the teachers' digital experiences and their use of Online Maths Websites.
- Hypothesis 3: There will be a positive relationship between the training teachers' have received on the use of the Online Maths Websites and their use of the OMWs.

6.2 Method

6.2.1 Design

The design included some comparisons between digital native and immigrant teachers' age, digital experiences, use of the OMWs and training for the first hypothesis. For the second and third hypotheses, the study followed the same correlational design from the previous two studies. The variables included in the study were the digital experience of teachers, their use of the OMW, and the training they received regarding how to use the OMW.

6.2.2 Participants

The participants who took part in this study were 105 teachers across the UK. There were no specific criteria in order to take part in the study apart from working in a primary school and using an online maths website with their students. The recruitment of teachers was carried out mainly through emails to primary schools and events related to schools (for example: Bath Taps into Science at the University of Bath). All teachers who took part in the study were assigned to a prize draw of £50. There were 86 females (81.9%) and 19 males (18.1%). The teachers were aged from 20 to 60 years old with just under half of them being in the 20-30 age group (40%) including both males and females.

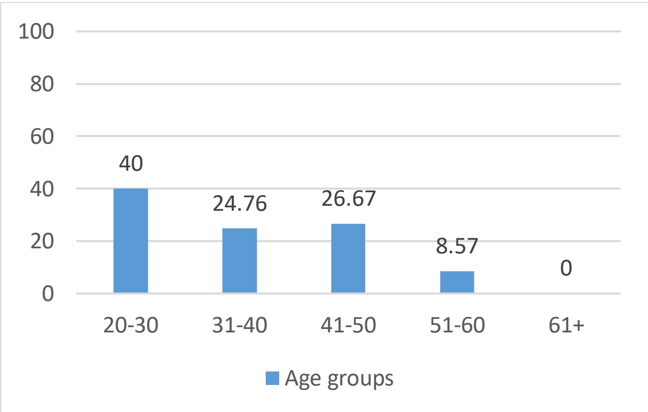

Figure 10 Teachers' age groups

Most of the teachers were from Bath (38.1%), Bristol (27.6%) and London (11.4%), while the rest were from different cities around the UK; Birmingham (2.9%), Reading (2.86%), Milton Keynes (1.9%), Liverpool (1.9%), Southampton (0.95%), Weeley, Frome, Trowbridge, Maryport of Cumbria, Ipswich, Wiltshire, Chippenham, Great Shefford, Brighton, Essex, Hemel Hempstead, Village.

6.2.3 Measures and Materials

The design of the questionnaire was very similar to the one completed by pupils and consisted of two parts. The first part included questions about the teachers' digital experiences at home and the second part included questions related to their use of the

Online Maths Websites and their training regarding these kind of websites. The questionnaire was designed to last approximately 10-15 minutes and to work on many different digital devices including mobile phones, so it can be easily accessed by teachers.

The design of the questionnaires was informed by the interviews with the teachers from study 1, the literature related to teachers' training and attitudes towards Information Communication and Technology (ICT), the students' questionnaire, and the European Computer Driving Licence (ECDL)[1] base module skills set. The ECDL skills set was used in order to specify what adults (in this case teachers) are expected to know regarding the use of ICT at a basic level.

6.2.3.1 Measures of Teachers' Digital Experiences; 1st part of the self-reported questionnaire

The digital experiences of teachers were measured in terms of access to different kinds of technologies, the frequency that these technologies were used, the breadth/range of uses, the confidence in completing specific tasks and the self-reported level of teachers' computer skills.

Access

The access to the 6 technological devices (listed below) was answered with a *Yes* or *No answer.*

i. *Internet*
ii. *Tablet*
iii. *Game Console*
iv. *Laptop*
v. *Mobile Phone*
vi. *Computer*
vii. *Electronic Circuits (Arduino, Raspberry-pi, Makey-Makey, Micro:bit)*

The only question that included more options was the one related to the access to electronic devices, where the teachers could choose to which of the following circuits

[1] http://ecdl.org/about-ecdl/base-modules

they have access at home; *Arduino, Raspberry Pi, Makey-Makey, Micro:bit, Other* (including an open space answer) and *None*.

Frequency

The frequency in which teachers were using these devices was measured in 3 following sub questions if the participant had answered positively to the question regarding the access to the specific digital device. The first 2 questions were related to the length teachers use the specific device in question during a weekday and during the weekend at home. Both questions could be answered in a 9 point scale (*0 = None, 15 = 15 minutes, 30 = 30 minutes, 60 = 1 hour, 120 = 2 hours, 180 = 3 hours, 240 = 4 hours, 300 = 5 hours, 360 = Over 5 hours*). The reliability of this measure was found to be adequate (Cronbach's alpha=.795). The third sub question asked teachers to answer how many times they used the device in question during the last week and they answered it on a 4 point scale *(0 = None, 1 = Once a week, 2 = Several times a week, 3 = Every day*). The reliability of this measure was also found to be adequate (Cronbach's alpha=.705).

Breadth

The breadth of uses was measured with the following list of activities:

i. *Communicate with others (friends, family, etc)*
ii. *Surf the web for personal activities*
iii. *Surf the web for Schoolwork*
iv. *Go on YouTube*
v. *Use the School's website*
vi. *Use word processing software like Word*
vii. *Create a video*
viii. *Use presentation software like Power Point*
ix. *Do some coding*
x. *Use the Online Maths Website/s*

The participants could respond to each action saying how often they do that on a 6 point scale (0 = *Never, 1 = Less than once a week, 2 = Once a week, 3 = Several times a week, 4 = Once a day, 5 = Several times a day*). The reliability of this measure was also found to be adequate (Cronbach's alpha=.795).

Confidence

The confidence that teachers have on the use of technology was measured with a list of actions based on the European Computer Driving Licence (ECDL) base module skills set. The ECDL skills set was used in order to specify what adults (in this case teachers) are expected to know regarding the use of ICT at a basic level. The participants were asked how confident they feel with a list of used that included the following activities:

i. *Computer and devices (ICT, software and hardware)*
ii. *File Management (Organise and storage folders)*
iii. *Data protection*
iv. *Touch typing*
v. *Printing materials*
vi. *Using the Web*
vii. *Using E-mails*
viii. *Online safety*
ix. *Using word processing software like Word*
x. *Using presentation software like Power Point*
xi. *Using spreadsheets like Excel*
xii. *Using text, photo, sound and video editing tools*

The participants could respond to each action saying how confident they felt when they had to do each action on a 5 point scale (0 = *Not Confident, 1 = A bit confident, 2 = Not Sure, 3 = Confident, 4 = Very confident*). The reliability of this measure was found to be good (Cronbach's alpha=.898).

Computer skills

Teachers' computer skills were measured on a 4 point scale (*1 = Poor, 2 = Good, 3 = Very Good, 4 = Excellent*). In order to raise the validity of the participants' responses and make sure that they were answering the questionnaire consciously, some of the questions were repeated in different ways and format. For example, the question regarding the teachers' computer skills, was also confirmed by their responses regarding if they had ever shown other teachers how to use the computer/tablet/laptop in a 4 point scale (*0 = Never, 1 = Sometimes, 2 = Quite Often, 3 = Always*).

6.2.3.2 Measures of Teachers' Use of Online Maths Websites; 2nd part of the self-reported questionnaire

The second part of the questionnaire started measuring the use of the OMWS for teaching in the classroom and homework purposes. Regarding the ***teaching in the classroom***, the questions included a *Yes* or *No* question asking teachers whether they use OMWs during their teaching in the classroom, how often they use it in the classroom (*0 = Never, 1 = Once, 2 = Twice, 3 = Three times, 4 = Everyday*), in what way they use it (*Teaching/Demonstration tool, Student individual activities, Student group activities, Whole class activities, Other*) and what tools they use for the OMWs (*Interactive Whiteboard, Computer, Laptop, Tablet, Whiteboard, Other*). The questions regarding the ***homework*** included whether they use it for homework purposes or not (*Yes or No*) and if yes, how often they give homework to their pupils (*0 = None, 1 = Once, 2 = Twice, 3 = Three times, 4 = Every time*). Teachers were also asked if they had received any kind of ***training*** regarding how to use the OMWs (*0 = Not at all, 1 = Not really, 2 = Undecided, 3 = Somewhat, 4 = Very much*). This question was followed by 2 further sub-questions regarding who delivered the training (*ICT coordinator of the school, Colleague from school, A friend out of school, Other; please specify*) and where they found extra support (*Online or Other; please specify*). The ***confidence*** teachers have when they use the OMWs was measured by the same 5 point scale as with the pupils (*0 = Not Confident, 1 = A bit confident, 2 = Not sure, 3 = Confident, 4 = Very confident*). The use of the OMWs was also measured in terms of ***time*** teachers spend ***online*** on these kind of websites in a typical day in an 8 point scale (*0 = None, 15 = 15 minutes, 30 = 30 minutes, 60 = 1 hour, 120 = 2 hours, 180 = 3 hours, 240 = 4 hours, 300 = Over 4 hours*) and the ***breadth of OMWs uses*** which could be answered in a 4 point scale (*0 = Never, 1 = Once a week, 2 = Several times a week, 3 = In every lesson*) and included the following options:

i. *Teach a concept*
ii. *Inform students' formative assessment*
iii. *Inform the planning of the next lesson*
iv. *Address students' difficulties in specific topics*
v. *Print students' reports for your use*
vi. *Print students' reports for parents' use and information*
vii. *Set specific individual tasks for different students*
viii. *Set tasks for the whole classroom*
ix. *Use the assessments tool to assign tests to your students*
x. *Create differentiated learning groups*
xi. *Print Certificates*
xii. *Use Demo tool for whole-class demonstration*

The reliability of this measure was found to be excellent (Cronbach's alpha=.912).

6.2.4 Ethics

The study was designed based on the ethical frameworks used by the University of Bath and the British Psychological Society (BPS) and all the relevant papers (e.g. information sheet, consent forms, debrief sheet) received full ethical approval by the Ethics Committee of the University of Bath (Reference Number 15-246).

(The questionnaire can be seen in Appendix D.)

6.2.5 Procedure

The researcher made a list of primary schools, emails and names of the schools' Head teachers from different cities around the UK based on information taken from the councils' websites. The researcher sent approximately 400 emails and follow-ups to schools and individual teachers inviting them to take part in the online survey. The emails included a brief introduction to the survey's aims and a link to the online survey. The head teachers were asked to disseminate the email to the teachers in their school and the individual teachers were asked to invite their colleagues to take part in the study. In order to reach the desired number of participants, the researcher followed a complementary strategy for recruitment which involved events targeted at primary schools, like Bath Taps into Science organised by the University of Bath, where teachers were asked to complete the survey on site.

6.3 Method of Data Analysis

The first step of the analysis was to download the SPSS file from Qualtrics with all the entries and recode some of them in order to be able to be computed in the different subcategories of the measures. More specifically, the digital experiences of teachers were measured in terms of *Access, Frequency*, *Breadth, Confidence* and level of *Computer skills*. It is worth mentioning here that the measures of access, frequency, breadth and confidence were collated. For example, in order to find the total access to different kind of digital devices the *Access* would be computed as following: *Access = Comp_access + Tablet_access + Laptop_access + Mobilephone_access + Gameconsole_access + Circuit_access + Internet_access*. The use of the OMW reported by teachers was measured in terms of *Frequency* that the teachers use the website, *Breadth* of uses, *Confidence* on the website and the *Time online* they spend on it. The *Breadth* of the online maths website use was also computed in a similar way like the subcategories of digital experiences.

6.4 Results

The results section presents the results of the hypotheses of the differences and relationships between the age of teachers, their digital experiences, their use of the Online Maths Websites and their training. The analysis of the relationships between the measures of the study used the Spearman's rank correlation coefficient nonparametric measure, because most of the variables used in the study were ordinal.

6.4.1 Differences between the measures of digital experiences, use of OMW and training between the digital native and immigrant teachers

The first hypothesis aimed to explore whether there are any differences between the measures of digital experiences, use of OMW and training between the digital native and immigrant teachers. Based on the concept of Digital Natives and Immigrants

(Prensky, 2001), it is expected that older teachers have less digital experiences and they use the OMWs less than younger teachers.

Hypothesis 1: There will be differences between the measures of digital experiences, use of OMW and training between the digital native and immigrant teachers.

Access

A Mann-Whitney U test was run to determine if there were differences in access to digital devices between digital native and immigrant teachers. Distributions of the access scores for native and immigrant teachers were similar, as assessed by visual inspection. Access score was not statistically significantly different between native (*Mdn*=4.00, *M*=4.35, SD=1.048) and immigrant teachers (*Mdn*=5.00, *M*=4.76, SD=1.116), U=1,496, z=1.660, p=.097.

Frequency

A Mann-Whitney U test was run to determine if there were differences in frequency of technology use between digital native and immigrant teachers. Distributions of the frequency scores for native and immigrant teachers were similar, as assessed by visual inspection. Frequency score was not statistically significantly different between native (*Mdn*=20.00, *M*=21.93, SD=11.369) and immigrant teachers (*Mdn*=18.00, *M*=18.73, SD=7.552), U=1,092, z=-1.111, p=.267.

Breadth

A Mann-Whitney U test was run to determine if there were differences in breadth of technology use between digital native and immigrant teachers. Distributions of the breadth scores for native and immigrant teachers were similar, as assessed by visual inspection. Breadth score was not statistically significantly different between native (*Mdn*=28.00, *M*=27.76, SD=8.255) and immigrant teachers (*Mdn*=26.00, *M*=25.41, SD=5.654), U=978, z=-1.877, p=.060.

Confidence

A Mann-Whitney U test was run to determine if there were differences in the confidence between digital native and immigrant teachers. Distributions of the confidence scores for native and immigrant teachers were similar, as assessed by visual inspection.

Confidence score was not statistically significantly different between native (*Mdn*=37.00, *M*=36.51, SD=8.316) and immigrant teachers (*Mdn*=35.00, *M*=34.97, SD=6.614), U=1,032, z=-1.519, p=.129.

Computer skills

A Mann-Whitney U test was run to determine if there were differences in computer skills between digital native and immigrant teachers. Computer skills scores were statistically significantly higher in digital native teachers (*Mdn*=3.00, *M*=2.96, SD=.818) than in immigrant teachers (*Mdn*=2.00, M=2.51, SD=.731), U=882, z=-2.683, p=.007.

OMW Frequency

A Mann-Whitney U test was run to determine if there were differences in how often digital native and immigrant teachers used the online maths websites. Distributions of the OMW Frequency scores for native and immigrant teachers were similar, as assessed by visual inspection. OMW frequency score was not statistically significantly different between native (*Mdn*=4.00, *M*=3.47, SD=1.067) and immigrant (*Mdn*=3.00, *M*=3.48, SD=1.282) teachers, U=721, z=.063, p=.950.

OMW Breadth

A Mann-Whitney U test was run to determine if there were differences in OMW breadth between digital native and immigrant teachers. OMW breadth score was statistically significantly higher in digital native teachers (*Mdn* =8.00, *M*=9.6308, SD=7.10978) than in immigrant teachers (*Mdn*=5.00, *M*=6.2000, SD=4.69543), U = 813, z = -2.349, p = .019.

OMW Confidence

A Mann-Whitney U test was run to determine if there were differences in confidence using OMW between digital native and immigrant teachers. Distributions of the OMW confidence scores for native and immigrant teachers were similar, as assessed by visual inspection. OMW confidence score was not statistically significantly different between native (*Mdn*=5.00, *M*=4.02, SD=1.546) and immigrant (*Mdn*=5.00, *M*=3.86, SD=1.700) teachers, U = 1,113, z=-.197, p = .844.

OMW Time Online

A Mann-Whitney U test was run to determine if there were differences in time spent on the OMW between digital native and immigrant teachers. Time spent on the OMW scores were statistically significantly higher in digital native teachers (*Mdn*=2.00, *M*=2.51, SD=1.120) than in immigrant teachers (*Mdn*=2.00, *M*=2.06, SD=1.058), U = 865, z = -2.065, p = .039.

OMW Training

A Mann-Whitney U test was run to determine if there were differences in OMW training between digital native and immigrant teachers. Distributions of the OMW training scores for native and immigrant teachers were similar, as assessed by visual inspection. OMW training score was not statistically significantly different between native (*Mdn*=1.00, *M*=1.40, SD=1.236) and immigrant (*Mdn*=1.00, *M*=1.76, SD=1.345) teachers, U = 1,384, z = .888, p = .375.

Based on the comparisons of the digital experiences, use of OMW and training between the digital native and immigrant teachers, the results showed that the distributions of the measures that were found to be significantly different are computer skills, OMW breadth of technology use and the time teachers spent on the OMW. The digital native teachers had significantly higher scores than the digital immigrant teachers in the above-mentioned measures. The two groups of digital native and immigrant teachers differed in three out of the ten measures of digital experiences and OMW use, thus, the first hypothesis of the study is partially accepted.

6.4.2 Relationships between the teachers' Digital Experience and the OMW use

The second hypothesis of the study explored whether the teachers' digital experiences influence the way they use the Online Maths Website (OMW). It is expected that the more digital experiences teachers have, the more they use the OMWs.

Hypothesis 2: There will be a positive relationship between the teachers' digital experiences and their use of Online Maths Websites.

Table 23. Spearman's rho correlation between Digital Experience and the OMW use

	Access	Frequency	Breadth	Confidence	Computer skills
OMW Frequency	-.013	.170	**.300****	.193	**.236***
OMW Breadth	.015	**.258****	**.393****	**.249***	.162
OMW Confidence	.074	.155	.054	.162	.063
OMW Time online	.102	**.238***	**.263****	.130	.067

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 23 shows there were no significant correlations between the access and the use of the Online Maths Website (OMW). However, it seems that the frequency teachers use digital devices is correlated positively with the breadth of uses on the OMWs (r=.258**, p<.01) and the time they spend on these websites as well (r=.238*, p<.05). Thus, the more time teachers spend on technologies, the more likely they will use a wider range of functions on maths websites and spend more time on them. In a similar way, teachers' breadth of uses on technologies is positively correlated to how often they use the OMWs (r=.300**, p<.01), the breadth of uses (r=.393**, p<.01) and the time they spend online (r=.263**, p<.01) on the maths websites. It is possible that the wider the range of uses on digital devices is, the more often teachers use the OMWs, the range of the different functions of the websites is wider, as well as the time they spend on them. The confidence in technologies in general is positively linked to the range of uses on the OMWs (r=.249*, p<.05), which means that the more confident teachers are in using technologies in general, the more functions they use on the maths websites. Lastly, teachers' computer skills are positively correlated to the OMWs frequency (r=.236*, p<.05), which shows that the greater computer skills teachers have, the more likely they are to use OMWs during the week.

Based on the results of the analysis, the second hypothesis is partially accepted, as there were statistically significant positive relationships between the teachers' digital experiences, in terms of frequency, breadth, confidence and computer skills, and their use of the Online Maths Websites. Thus, it can be argued that the way teachers use technologies at home in their everyday life does influence how they also use the OMWs.

Next the analysis explores the relationship between the type of digital experience teachers have and their use of Online Maths Website.

Table 24. Spearman's rho correlation between OMW Frequency and specific uses of Breadth

	OMW Frequency
Communicate with others (friends, family, etc)	**.247***
Surf the web for personal activities	.167
Surf the web for Schoolwork	.095
Go on YouTube	.116
Use the School's website	.167
Use word processing software like Word	.138
Create a video	.123
Use presentation software like Power Point	.024
Do some coding	**.250***
Use the Online Maths Website/s	**.576****

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 24 shows there are a few significant positive correlations between the frequency teachers use the OMW and the type of digital experience. There was a positive relationship between use of OMW and communicating with others (r=.247*, p<.05), doing some coding (r=.250*, p<.05) and using the online maths websites (.576**, p<.01). It is also worth mentioning that the when the same analysis is run for the teachers' confidence on the website and the specific uses of Breadth, there were no significant correlations.

Table 25. Spearman's rho correlation between OMW Confidence and specific uses of Confidence

	OMW Confidence
Computer and devices (ICT, software and hardware)	.119
File Management (Organise and storage folders)	**.205***
Data protection	.123
Touch typing	-.082
Printing materials	.175
Using the Web	.113
Using E-mails	.179
Online safety	.052
Using word processing software like Word	**.223***
Using presentation software like Power Point	**.214***
Using spreadsheets like Excel	.192
Using text, photo, sound and video editing tools	.085

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 25 shows some significant, although weak, positive correlations between how confident teachers are on the use of the OMW and specific uses of confidence. More specifically, OMW confidence is positively related to uses such as file management (r=.205*, p<.05), using word processing software like Word (r=.223*, p<.05) and using presentation software like Power Point (r=.214*, p<.05). Table 25 seems to suggest that teachers who use their digital devices for purposes related to schoolwork are the ones who are more confident on the use of the OMWs.

6.4.3 Relationships between the OMW use and OMW training

The third hypothesis explored the relationships between the use of the OMWs and the training teachers received on how to use them. More specifically it explores whether the training teachers received is linked to the way teachers use the OMWs. It is expected that the more training teachers receive the better their use of the OMWs will be.

Hypothesis 3: There will be a positive relationship between the training teachers' have received on the use of the Online Maths Websites and their use of the OMWs.

Table 26. Spearman's rho correlation between the OMW use and OMW training

	OMW Training
OMW Frequency	.172
OMW Breadth	**.227***
OMW Confidence	.153
OMW Time online	.180

*. Correlation is significant at the 0.05 level (2-tailed).

Based on Table 26, the training that teachers receive on how to use OMWs is positively correlated to the breadth of uses ($r=.227^*$, $p<.05$), which could mean that the more training teachers get, the more functions of the websites they use.

Thus, it could be argued that the hypothesis is partially accepted, since there is a positive relationship between the measures of OMWs use and the training teachers receive.

(The descriptive statistics of the study can be seen in Appendix E.)

6.5 Discussion

The aim of the study was to explore the differences and relationships between the teachers' digital experiences, their use of Online Maths Websites (OMWs), their training on these websites and the role that their age plays in the above. The study found that there are a few significant positive correlations between the ways that teachers use their digital devices at home and the ways they use the OMWs. In addition, the training that teachers receive in relation to how to use the OMWs is also positively linked to the OMW breadth of uses, which means that the more training the teachers get, the more functions of the OMWs they use. The analysis in relation to the groups of digital native and immigrant teachers revealed differences between the native and immigrant teachers in three out of the ten measures used in the study. More specifically, the native teachers seemed to have better computer skills, wider breadth of OMWs uses and spend more time on the OMWs than the teachers in the digital immigrant group. The results offer an insight into how teachers use the OMWs in relation to their digital experiences, their training and age.

6.5.1 Differences between Digital Native and Digital Immigrant teachers

The study explored the differences of digital experiences, use of OMWs and training between digital native and immigrant teachers. The results revealed the existence of some differences between the two groups. More specifically, findings suggest that the digital native teachers reported better computer skills, wider breadth of OMW use and longer time spent on the OMW than the digital immigrant teachers did. The study agrees with the research conducted by Howlett and Waemusa (2018) who found that the digital native teachers had better computer skills than their digital immigrant colleagues. However, the findings contradict previous findings by Johnson (2018) who found that the only difference between the digital native and immigrant teachers was that the digital immigrant teachers were using the online resources in their classrooms more than the digital native teachers did. It seems that both the current study and the study conducted by Howlett and Waemusa (2018) partially support the concept by Prenksy (2001) and the differences between the two groups. However, the fact that there is also data that contradict these findings by Johnson (2018) stresses the complexity of the issue and the need for further research in order to get a more complete understanding of the situation.

6.5.2 Relationships between the Digital Experiences of teachers and their use of the OMWs

There were a few positive relationships between the digital experiences of teachers and their use of the OMWs, which indicates that they both influence each other. More specifically, the OMW frequency was positively linked to the breadth of uses and the computer skills that the teachers have, which suggests that the greater the breadth of use and the better computer skills of the teachers, the more frequently they use the OMWs. Furthermore, the breadth of the OMWs was also positively linked to the frequency of use of digital devices the breadth of use and the confidence that the teachers have when they use technology. The more frequently a teacher uses technology, the wider the breadth of uses is and the more confidence they have, the more functions of the OMWs they use. The confidence teachers have using OMWs was not related to any of the digital experiences measures. However, the time the teachers spend online while using the OMWs was positively linked to the frequency and breadth of uses of their digital devices.

The results of the teachers partially agree with the results of children in the previous two studies. More specifically, teachers' confidence and computer skills were both linked positively to the teacher's use of OMWs, as was also found for the children. However, the measures of digital experience that were linked to most of the OMW measures were the frequency and breadth of technology use, which supports the fact that the ways they use technologies in their everyday lives is linked to how they use the OMWs. This is supported by research conducted by Olofson, Swallow, and Neumann (2016) who argued that the familiarity of teachers with technology is one of the main reasons that influence the ways teachers use technologies in their teaching. The only digital experience measure that was not linked to any of the OMW measures in children and teachers' studies was the access to different kind of technologies. This supports previous research by Liabo, Simo and Nutt (2013) who suggested that the literature should move forward from the concept of digital divide to the concept of *the second-level of digital divide,* which moves away from just the access to technologies and stresses the fact that what counts most is the ways that technology is used.

In order to get an insight into which specific uses affect the ways teachers use OMWs, the study tested the relationships between OMW use and specific uses of digital devices. Findings suggest that the OMW frequency was positively linked to coding, while the OMW confidence is positively linked to the way teachers use file management, and software of word and power point. It could be argued, like in the case of the students, that teachers who use their digital devices for purposes related to schoolwork are the ones who are more confident on the use of the OMWs.

6.5.3 Relationships between the OMW training and OMW use

The training that teachers receive in relation to the use of OMWs was one of the main issues brought up in the first study of the thesis and it was considered important to be examined within this study with the teachers. The study explored the relationships between the training teachers receive on the OMW use and the ways they use the OMWs. The analysis revealed that the training was positively linked to the OMW breadth of uses and it could be argued that the more training the teachers get, the wider the breadth of uses of the OMWs is. This finding agrees with research conducted by Mahmud and Ismail (2010) who found that the ICT training influences significantly how teachers use technology. It is worth mentioning here that more than half of the teachers reported receiving no training or not really any training and only a third of them said they had training. This is an indication that schools should try provide training related to how online maths websites are used in order teachers to learn different ways to use them in their maths teaching and assessment. Orlando and Attard (2016) have also stressed the importance of training as a necessity for both digital native and immigrant teachers in order their use of ICT to be efficient.

6.6 Conclusions

The fourth and final study of this thesis investigated the relationships between the digital experiences of teachers, their use of OMWs and the training they receive on how to use the OMWs. It was considered essential within the thesis to investigate both sides of the situation; children and teachers, as most research focuses on the students and how much they have changed due to the use of technology in comparison to previous generations. Findings suggest that teachers' digital experiences at home affect the ways they use the OMWs at school. Especially the measure of breadth of use seemed to be linked to all the measures of the OMW use; the frequency, the breadth, the time online, apart from the confidence.

In addition, the study examined the notion of digital natives and immigrants amongst teachers themselves instead of examining teachers versus students, which is an approach that has not been taken by many other researchers until now. It was found that the differences between the two groups of native and immigrant teachers were detected in their computer skills, the OMW breadth of uses and the time they spend on the OMW with native teachers having significantly higher scores in all three categories. It could be argued, as Helsper and Eynon (2010) suggested that some of the digital natives do acquire unique skills in the use of technologies, but the digital immigrants could work on their ICT skills and close the gap between the two.

7. Chapter of Discussion

7.1 Introduction

This chapter provides a discussion of the findings of the thesis in relation to the research questions and the theoretical frameworks addressed. It starts by re-stating the problem/gap in the literature, the necessity of this research and a brief summary of the findings of each of the four studies. It then continues with the contribution to knowledge of the thesis in terms of the development of the model of the Educational Digital Divide, the myths and realities behind Digital Native and Immigrant children and teachers, their use of online maths websites and the methodological approach used in the thesis with the combination of self-report and usage data. The chapter discusses the limitations of the thesis, the implications that arose from it and suggests some interesting paths for future research.

7.1.1 Re-stating the problem

Technology is becoming one of the most important aspects of children's lives and it is embedded in most of their everyday activities at home and at school. Most children who have started school in the last few years have been raised surrounded by technology and this has led authors to argue that education should change in order to include new and more sophisticated ways of teaching and learning with the use of new technologies (Prensky, 2001, 2010; Tapscott, 1998, 2009; Green & Hannon, 2007; Thomas, 2011). Although this change has already happened to a degree, with the use of whiteboards, laptops and tablets within schools, one of the aspects of education that has not changed until recently is assessment. Until last year technology was only used as part of the formative, day to day assessment of pupils in primary schools. However, in the last couple of years the Department of Education (DfE) has been discussing the introduction of a new online on-screen assessment for times-tables in primary schools. After piloting this new framework the DfE announced that the new on-screen assessment will be compulsory for all students in Year 4 from the academic year 2019/20. This will be the very first summative assessment using computers and laptops in primary schools in the UK.

However, there is an ongoing debate regarding whether children are actually as tech-savvy, as many people believe them to be, or is there a big variation in children's technological skills. As discussed in this thesis, there is limited research on how children use technology at home and school and how that influences their performance. This thesis aimed to investigate whether the use of technologies at home and school by children and teachers are linked to their use of online maths websites and their performance on these websites.

7.2 Summary of findings for each study

7.2.1 Study 1

Study 1 aimed to explore the perceptions and experiences of teachers and children regarding the use of technologies in educational assessment and the ways that the integration of technology into assessment might affect students' feelings and performance. The research questions that framed the study were the following:

- What are the primary teachers' perceptions and experiences regarding technologies in educational assessment?
- What are the primary students' perceptions and experiences regarding technologies in educational assessment?
- In what ways does the integration of technology into assessment affect students' feelings and performance?

The results showed that teachers use new technologies in assessment mainly for inputting data on the school's system, tracking children's performance, as a resource for information and for using online maths websites. It is worth mentioning the online maths websites was the only technology used both by teachers and children. The perceptions of both teachers and students concerning technology for assessment were quite similar. The advantages included instant feedback and improvement of quality of work, and the disadvantages included their technological skills, fear/lack of trust of technology and practical issues like the fact that schools do not have equal number of digital devices for all children. A common theme in almost all the interviews with both children and teachers was the fact that they all use many different online maths websites to set weekly homework for their students. The fact that this was the most common, frequent use of technologies for assessment purposes and it was also on the subject that the DfE was planning on introducing the use of technologies for summative assessment, was the main reason why the second study focused on the use of online maths websites.

7.2.2 Study 2

After identifying a common use of technology for purposes of assessment, it was considered important to explore further how the online maths websites are used by the children and whether their use and performance on these websites is dependent on their digital experiences. Thus, study 2 investigated the relationship between the children's digital experiences, their use of online maths websites and their performance on the website. It tested the following hypotheses:

- Hypothesis 1: There will be a positive relationship between the children's digital experiences and their school year and age.
- Hypothesis 2: There will be a positive relationship between the children's digital experiences and their self-report use of Online Maths Websites for their homework
- Hypothesis 3: There will be a positive relationship between children's use of Online Maths Websites and their self-report performance on these websites

The results showed that the frequency children were using the online maths websites was linked to the frequency and breadth of the use of technologies at home, as well as their computer skills. The confidence they had with the use of the OMWs was linked to their confidence with technology in general and their self-reported performance on the OMW was linked to the confidence they had using the OMW. The findings also suggested that both breadth of uses and confidence were linked to the age and school year of the children and that could mean that older children have a wider range of technology uses and they were more confident on how to use technologies than the younger children were. The results of this study were all based on self-reported data from the children and it was considered important to find a way to examine whether the self-reported data matched with the usage data of use from the online maths websites. In order the researcher to achieve that, she established a collaboration with one of the most widely used online math website, Mathletics.

7.2.3 Study 3

Study 3 was a replication of study 2 with the addition of the usage data of children's use taken from the database of Mathletics. Study 2 tested the following hypotheses:

- Hypothesis 1: There will be a positive relationship between the children's digital experiences and their school year and age.
- Hypothesis 2: There will be a positive relationship between children's digital experiences and their self-reported use of Mathletics for their homework
- Hypothesis 3: There will be a positive relationship between children's use of Mathletics and their self-reported performance on Mathletics
- Hypothesis 4: There will be a positive relationship between children's digital experience and the actual usage data from Mathletics
- Hypothesis 5: There will be a positive relationship between the children's self-reported use of Mathletics and the actual usage data from Mathletics

The results showed that there were some weak/moderate positive relationships between the self-reported data by the children and the usage data taken from Mathletics. This finding suggests that the self-reported data collected by children can be trusted. Study 3 replicated some of the findings from study 2. One such example is that the confidence that children use the online maths websites was linked to the confidence and computer skills that children have when they use computer, which was the same finding as in study 2. In the same way, confidence was also linked to the self-reported performance of students on the website. However, the actual performance was positively linked to the frequency and confidence that children have using technologies only in the third study but not in the second. In relation to the digital experiences of the children and their age, it was found again that confidence is linked to both the school year and age of children, meaning that the older children were more confident using technologies.

7.2.4 Study 4

In order to gain a more complete picture in relation to the topic, study 4 explored the digital experiences of teachers and their use of online maths websites. Study 4 tested the following hypotheses:

- Hypothesis 1: There will be differences between the measures of digital experiences, use of OMW and training between the digital native and immigrant teachers.
- Hypothesis 2: There will be a positive relationship between the teachers' digital experiences and their use of Online Maths Websites.
- Hypothesis 3: There will be a positive relationship between the training teachers' have received on the use of the Online Maths Websites and their use of the OMWs.

Results revealed that digital native teachers differed from digital immigrant teachers, as the study showed that digital native teachers have better self-reported computer skills, breadth of OMW uses and spent more time online compared to digital immigrant teachers. In terms of teachers' digital experiences and the use of the OMW, results also showed that the frequency, breadth of use, confidence and computer skills teachers have are linked to how they use the online maths website. The training that teachers received for the use of the OMW was linked to one of the measures of the OMW use, the breadth of uses. This suggests that the more training the teachers have on the use of the OMW, the wider the breadth of uses is.

7.3 Contribution to knowledge

7.3.1 The Educational Digital Divide; from a pyramid towards a continuum

The results in relation to children's digital experiences at home and the ways that they use online maths websites for their schoolwork showed that the pyramid of the Educational Digital Divide model by Hohlfeld et al. (2008) is even more complicated than it seems. This is mainly because the different routes that a student can take to reach his/her technological empowerment are many and they do not always have to go through the classroom.

Based on the results of the thesis, it could be argued that the Educational Digital Divide could be related to the digital experiences that the children have at home. Results from study 2 and 3 showed that children's computer skills are linked to how children use digital devices at home and there is a big variation in technological skills amongst students. Thus, the digital experiences the children gain from their interaction with technologies at home help to shape their computer skills. For this reason, it is considered important to include the home aspect in the model. The following figure was created as a development of the model by Hohlfeld et al. (2008), as it suggests that home and school are two parallel systems that both influence children's use of technologies and their routes to technological empowerment.

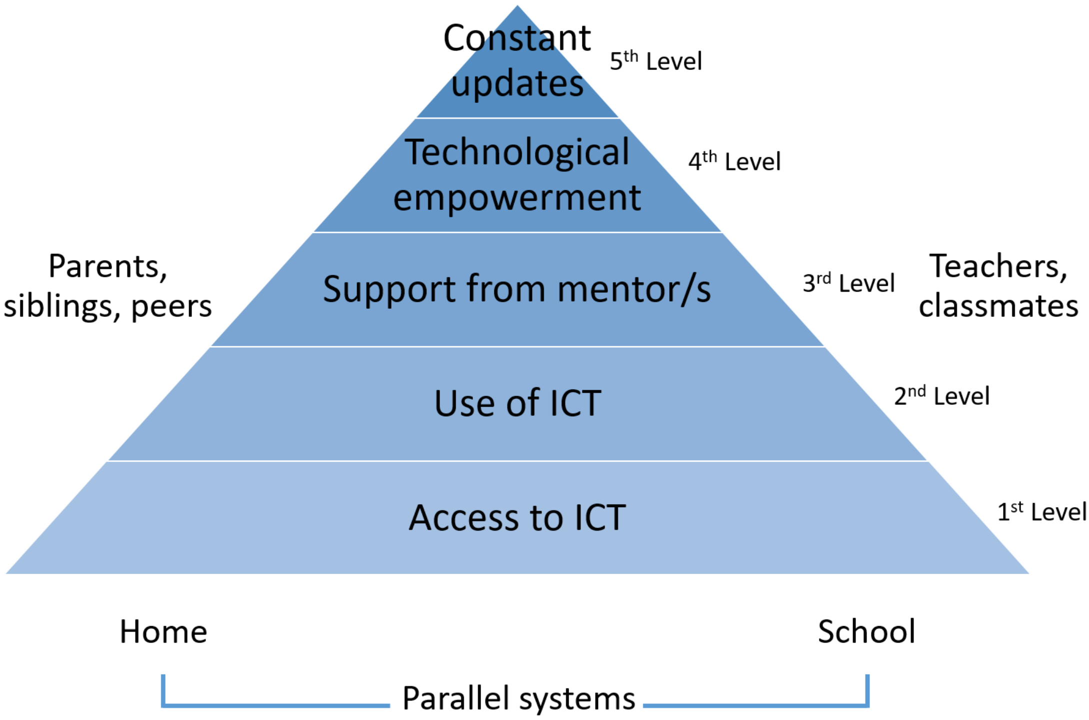

Figure 11 Further development of the Educational Digital Divide model

As Figure 11 shows, the main route to technological empowerment as illustrated in the pyramid model remains the same, with access to ICT being the very first step in the process of building a child's computer skills. The parallel system here suggests that even if a child does not have access to technologies at home, he/she might have access to different digital devices at school, and vice versa. If the schools does not have any technologies that does not mean that the child does not also have access to technologies at home. However, if both home and school do not have digital devices, then the divide is clear, as the child will not have the opportunity to interact with any technologies. If the access to technologies is established by at least one system, home or school, then the child can move to the second level of the model which is the use of ICT.

At the second level of the model and based on one of the findings of this thesis, the computer skills that the children develop are linked to how they use technologies at both home and school. Even if a child does not have as rich experiences with technologies at school, they can use digital devices at home in many different ways, and thus, the child will not be left behind. On the contrary, he/she will be able to move forwards to the next level of model.

The third level of the model refers to people who help children build their technological skills even further. These people can be their parents, siblings, peers and/or their teachers and classmates. Children usually practice their computer skills by spending time on the use of different technologies and by trying a wide range/breadth of activities. However, if they are also helped and guided by another person/mentor who has knowledge related to technologies, then they can improve their skills even more. This is also supported by theory based on work by Vygotsky (1978) and the zone of proximal development, but also by evidence discussed in the literature review which suggests that children are not experts in the use of technologies (Kirschner & De Bruycker, 2017; Sorrentino, 2018) and it would be a mistake to take their technological knowledge as a given, as that might prevent teachers from teaching them higher technological skills (Thompson, 2013; Kirkwood, 2006, 2008). When the students have the guidance and support they need, either or/and at home, in order to develop their skills further, then they can reach the level of technological empowerment. This is also related to scaffolding, which is a term commonly used in education to show how specific kinds of help and support that children receive when they interact with their teachers, parents or peers can help them reach higher-level skills and knowledge (Maybin, Mercer & Stierer, 1992).

A child can be technologically empowered after having access to technologies, using digital devices in a broad way and by having some help and support to develop their computer skills. When a child is technologically empowered then they can apply their computer skills to different software and hardware, have a deep understanding of how digital devices work and can use them for the betterment of their lives (Kim & Kim, 2001).

The last addition to the Educational Digital Divide model, the level of constant updates and new information in relation to ICT, is stressing the fact that even if students become technologically empowered by the interaction they have with technologies at home and school, technology changes so fast, that they should still make effort to update their knowledge and skills at regular intervals. This level emphasizes the fact that technological empowerment is not the end of the model, but the model remains open and requires continuous efforts from the child/person in order to ensure that they remain empowered.

Thus, these two parallel systems of home and school can be seen as complementary to each other, as even if development is not supported by one system, it might be supported by the other system and the child can continue to build their technological knowledge further. The model also stresses that teaching children higher technological skills is an important step towards their empowerment and it should be shown on the graph as an extra level/step for a child to become technologically empowered.

7.3.2 The myth and reality of Digital Natives, and confidence as a new factor linked to technological skills

The fact that the school year and age of children were positively linked to some of the different measures of children's digital experiences (access, frequency, confidence) suggests that the digital experiences of children are changing with the passage of the years and the older children get, the more they use technologies and the more confident they are with them. This seems to support the extensive literature which suggests that the digital experiences of children are far from universal (Jones, Ramanau, Cross & Healing, 2010; Kennedy et al., 2008) and there is no distinct generation with high level technological skills (Helsper & Eynon, 2010). The age factor is only one, amongst many other interrelated factors, that influence how children use technologies (Jones & Hosein, 2010). These findings are in agreement with research by Bhroin and Olafsson (2011) who found that children did not seem to acquire all the technological skills they were thought to have.

Results from the current studies showed that one of the most important factors in relation to how children use the Online Maths Websites and how they perform on them is the confidence they have in using technologies. Confidence was the factor that was found to be linked to both children's use of the OMW and performance in both studies 2 and 3, while the factors of access, frequency, breadth and computer skills were not consistently linked to OMW use or performance. The confidence that children have using technologies was positively linked to both the school year and the age of the students, which suggests that confidence in using digital devices is changing through the years and it is not innate from the very early years of the child. It is worth mentioning that confidence was found to be positively linked to their age and school year in both studies (2 and 3), while other factors such as the breadth of uses was positively linked to the age and school year only in the second study and access and frequency were positively linked to the age and school year only within the third study. The breadth of use has been found to be an important factor in terms of children's technological skills in previous research (White & Le Cornu, 2011; Helsper & Eynon, 2010; Jones & Shao, 2011), but confidence has not been mentioned in previous research. This means that confidence could be considered as important as the pre-existing factors of socioeconomic background, breadth of uses, gender, and ethnicity that have been researched in relation to the concept of digital natives.

When Prensky's framework is seen superficially, it seems to be right and is widely accepted by the public, as it is based on common sense and most people have at least one experience of seeing children engaging enthusiastically with technology demonstrating some sort of expertise from an unexpectedly young age. However, in most of these occasions children engage with technology for purposes of entertainment and not in an educational context. Thus, the research of this thesis, which is done on children's actual technological engagement in maths assessment rather than assumptions, is of primary importance and critical for all people working in the educational sector; from teachers and parents to people working at the Department of Education and policy makers. The findings of this thesis make a valuable contribution to the debate of digital natives and highlight the effects of breadth and frequency of engagement at home with subsequent engagement with online maths platforms. The thesis contributes to the shift of the focus of future research from the myth of the technologically savvy children to aspects such as children's frequency, breadth and confidence of technology use in an educational context.

7.3.3 The reality of Digital Immigrants

The existing literature in relation to Digital Natives and Immigrants (Prensky, 2001) has mainly focused on the children as digital natives, but there is very limited research exploring the transition of digital native students to digital native teachers and the differences between the native and immigrant teachers in primary schools. The fourth study of this thesis has offered evidence on the differences between these two groups that did not exist before.

The findings concerning the teachers in study 4 suggest that there are generational differences between digital native and immigrant teachers. The study revealed that the digital native teachers have better computer skills, a wider breadth of uses and they spend more time online. These findings agree with previous research by Howlett and Waemusa (2018) who also found that digital native teachers had better computer skills than their immigrant colleagues.

However, it could be argued that the contradicting evidence in the study by Guo et al. (2008) which failed to find any difference between age and ICT competency amongst pre-service teachers can be explained by the fact that the study was conducted more than 10 years ago when the digital native teachers did not have the same training on the use of ICT as younger teachers today have. Thus, it might be that the differences between digital native and immigrant teachers have become more apparent in the last few years, because the younger teachers who belong in the group of digital natives have received training on ICT as part of their Postgraduate Certificate in Education (PGCE) course. An example of such training is the course offered by the University of East London called the PGCE Primary with ICT and computing and provides considerable training in the use of ICT. This training was not available at all, or not available at the same extent, to the digital immigrant teachers and they had to learn how to use technologies by themselves or with the help of colleagues. Thus, a possible explanation of the difference between the two groups is not the fact that digital natives use digital technologies more, but because they have received more training on it. However, the fact that among the 10 measures used in the study, only 3 of them included differences between the two groups, that might mean that as Helsper and Eynon (2010) have suggested, digital immigrant teachers could work on their ICT skills and close the gap between them and their digital native colleagues.

7.3.4 Digital experiences of children, their use of Online Maths Websites and their performance

The thesis has offered an understanding of the relationship between the digital experiences of children, their use of online maths websites and their performance on these websites. Studies 2 and 3 revealed the links between the digital experiences of children and their computer skills.

Results from study 2 suggested that the frequency of technology use is linked to breadth of use, then both frequency and breadth are linked to confidence, and finally, breadth and confidence are related to the computer skills children have. However, the access to different kind of technologies does not seem to play any role in how children use technology. It could be argued that all different aspects of frequency, breadth and confidence play a role in the development of children's computer skills. The results agree with previous research which has also identified that the factor of breadth of use is linked to how children use technologies (Helsper & Eynon, 2010; Jones & Shao, 2011).

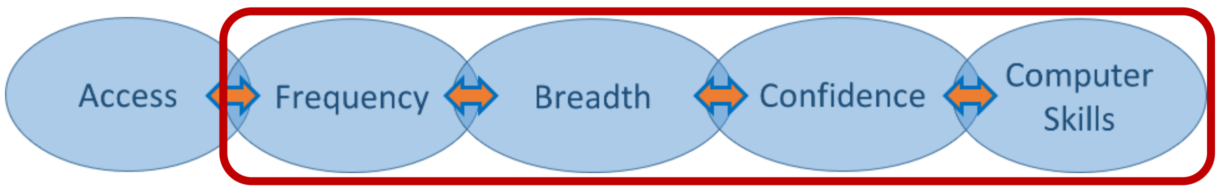

Figure 12 Visual representation of the relationships between the measures of Digital Experiences of children from study 3 and the common findings between the 2 studies (in red box).

Figure 12 shows that in the third study of the thesis all different factors of children's digital experiences were linked to each other. This finding is consistent with the findings of study 2 but the only difference is that the access to technologies is also linked to the rest of the factors. Based on both models, it seems that the computer skills of children are linked to the following 3 different factors of digital experience; frequency, breadth, and confidence. It could be argued that when children spend enough time on the use of technologies, they use different digital devices for many different reasons and they are confident in their use, then their computer skills are also good.

In relation to the links between the students' digital experiences and their self-reported use and performance on the websites, figure 4 shows that the common pattern between the 2 studies is focused on the links between the confidence and computer skills of children and the confidence with which they use the OMWs. The fact that this was common in both studies means that confidence does play an important role in how students use the websites. However, the children's self-reported performance was linked to confidence and computer skills only within the 3rd study of the thesis, while in the 2nd one it was not related to any factors of digital experience.

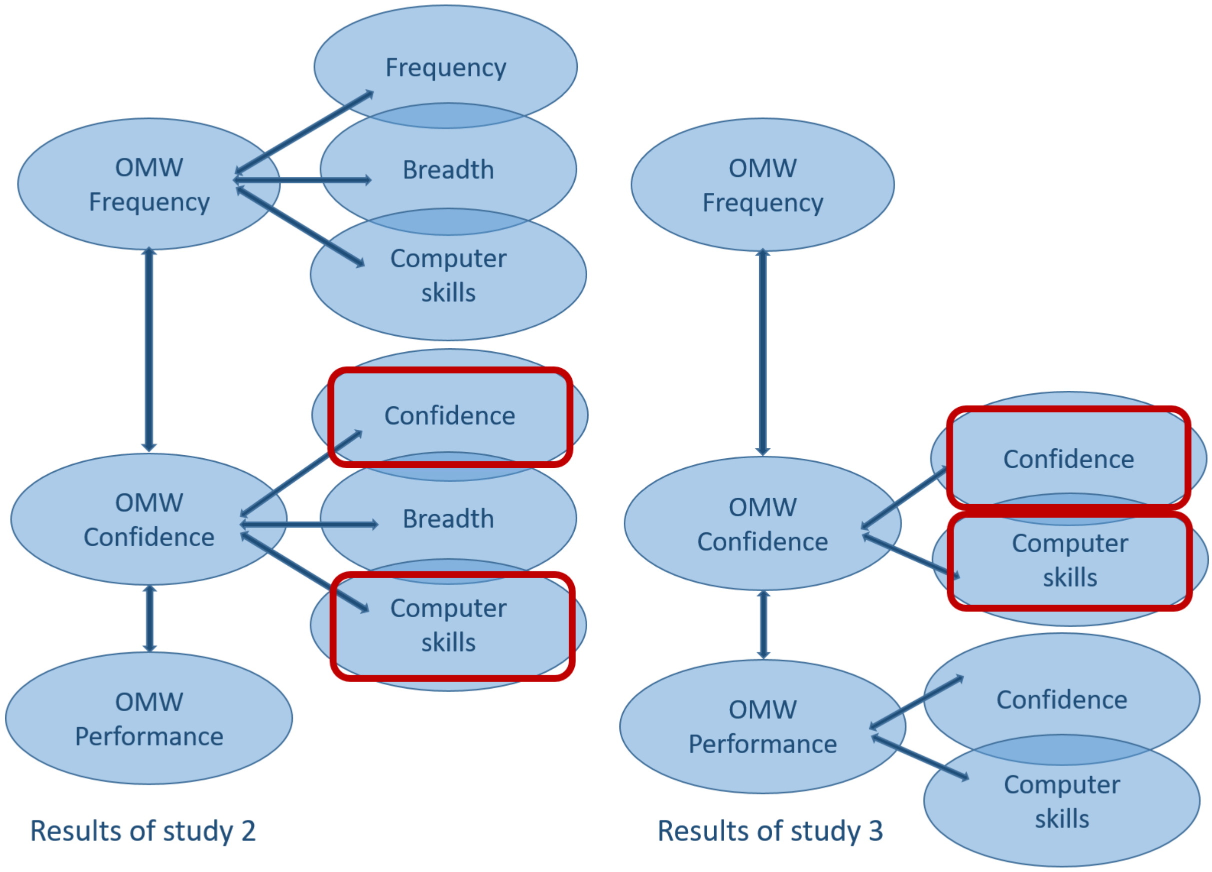

Figure 13 Visual representation of the relationships between the measure of the Online Maths Websites and the Digital Experiences of children from study 2 and 3 and the common findings between the 2 studies (in red boxes).

As is shown in *Figure 13*, the frequency and confidence of the use of online maths websites were both linked to the performance of the students. Thus, it could be argued that even if the ways children use technologies at home are not directly linked to their performance, they make a change to the frequency and the confidence with the OMWs, and thus, on performance as well.

It is worth mentioning that the actual maths performance of the children was also positively linked to the frequency and confidence on general technology use. Thus, it could be argued that the most interesting part of the findings is the fact that confidence with the use of technologies and on the use of the online maths websites is shown to be an important factor of children's digital experiences, as it was also shown for the age and school year of children. Thus, it could be argued that this is a factor that is significant in both studies and is linked to some of the rest of the factors, like frequency, breadth, computer skills and online maths performance, which could be used in teaching as discussed in the implications of the thesis.

7.3.5 Methodological

This section reports the methodological contributions to knowledge in relation to the inclusion of role play as a data collection method in study 1, the development of the questionnaire which used to measure the digital experiences of children and teachers in studies 2, 3 and 4, and the use of self-report and usage data in study 3.

7.3.5.1 Role-play as data collection method

According to Ginsburg (1978) and Cohen et al., (2011), role-playing has been used for many years in experiments for social psychology as a method to assess personality, as a training tool in business and as a therapeutic procedure. However, there is only a very small number of studies, which have used role-playing in educational research (Cousins, 1999; Evans & Fuller, 1996; Finch, 1998; Kakos, 2005; Miller, 1997).

The thesis has offered a new, innovative perspective for the use of role-play activities as a data collection method in research with children. The role-play activity that was used as part of the children's interview protocol helped the children distance themselves from basic elements of technology, such as entertainment, and gave them a more critical, complex perspective, that of the teacher. The fact that the role-play activity had worked successfully in this study was evident on the differences between the responses the children gave when they were prompted to comment on the collage images showing children taking tests on paper and computers and the responses they gave during the roe-play as teachers. It was observed that at the first activity with the images, the children were quite enthusiastic about the prospective of being assessed on digital devices. However, when they were asked to become teachers themselves and decide the mean (paper or technology) that they would assess their own students with, they started thinking more critically of the introduction of technology in assessment and they even considered issues of familiarity of students with technologies, and issues of fairness and practicality.

An activity like that can be particularly useful in exploratory studies with children, where the aim of the research is to gain a good understanding of a situation and capture the perspectives of children without having to lead them with specific questions. Role-playing can be used as a powerful tool that can capture children's thoughts and feelings in a free, clear way (Clark, 2005; Kakos, 2005). However, it has to be mentioned that role-play activities cannot be as successful in different scenarios. Van Hasselt, Hersen, and Bellack (1981) conducted a study to test the validity of role-play tests for assessing social skills in children and they found that there was little association between the results given from role-play activities and natural settings. Thus, although the use of role-playing can be a successful method of data collection, it is a time-consuming process that needs very careful organisation and planning and should be used as a complementary method of data collection and not a replacement (Cohen et al. 2011; Kakos, 2005).

7.3.5.2 Development of Digital Experience Questionnaire

As discussed in study 2, literature on children's digital experiences does not include a recent, timely questionnaire that is addressed to children and could be used in the thesis to measure children's use of digital technologies at home. For that reason, it was considered essential the researcher to develop a new questionnaire for the aims and the research questions of study 2. The questionnaire was developed based on the findings of study 1, the literature related to children's digital experiences and the two theoretical frameworks used in the thesis (Helsper & Eynon, 2010; Hohlfeld et al. 2008; Jones & Shao, 2011; Kennedy et al. 2009; Livingstone et al. 2014; Prensky, 2001; Sorrentino, 2018), previous questionnaires in relation to technology use by children (Downey, Hayes & O'Neill, 2007; Livingstone, et al. 2011) and the ICT curriculum of one of the schools.

The digital experiences of children were measured in terms of *access* to different types of technologies, *frequency* of use of these devices, *breadth* of use, *confidence* and *computer skills*. The measure of *access* was based on the digital divide and the model of educational digital divide. The measures of *frequency* and *breadth* of use were developed and included in the questionnaire based on previous literature suggesting that research should be move away from exploring technology use based on the age of the user and focus more on investigating how technology is used (Jones & Shao, 2011; Sorrentino, 2018). The shift of the focus from the access to technology to the use of technology is also referred as the second-level of digital divide (Hargittai, 2002; Liabo, Simon & Nutt, 2013). The measures of *confidence* and *computer skills* were also developed based on the fact that there is extensive discussion in relation to whether the confidence that children have on the use of technologies is only related to entertainment and not higher levels of computer skills (e.g. Livingstone et al. 2014).

The questionnaire appears to be reliable, as it was tested for internal consistency, where Cronbach alpha's results were from adequate to excellent, which also shows that there is consistency of people's responses across the items on the multiple-item measures. Moreover, the questionnaire developed for studies 2 and 3 has also strong face validity, as it measures the variables that intends to measure by developing these measures based on the current literature discussed in the introduction and the theoretical frameworks of the thesis. It has to be mentioned, that although the test was used twice in two different studies, the test-retest criterion for the questionnaire's reliability could not be added as a hypothesis in study 3, as the measure was not tested with the same population.

Thus, it can be argued that the thesis has offered a measure for children's digital experiences, which appears to be reliable and valid and did not exist in the literature. However, it has to be stressed that the specific measure was developed based on the research questions and the aims of the specific thesis and has fulfilled those, but it would need further work if it will be used in a different research project. In addition, the reliability testing that was conducted on it could be taken further in order to for this questionnaire to be considered a measure that can be applied in different projects.

7.3.5.3 Self report & Usage data

The thesis offered a new and innovative way of collecting data to explore the relationship between the digital experiences of children and their use and performance on OMWs. More specifically, the third study of the thesis used a combination of self-reported data by children and usage data from the database of Mathletics in order to gain a better understanding of the relationships between the two. The self-reported data from children have been matched with the usage data of use from the website and the results revealed that four out of five measures of the relationships between self-report and actual use measures were positively correlated. The measures that were positively linked were the self-reported and actual time the children spend on the website, the attempts they take for each task, the activities they complete at school and the activities completed at home, while the only measures of self-reported and usage data that were not linked to each other were the ones related to the children's performance on the website (see Table 222, p.150).

Although the relationships were low and not enough to confirm the reliability of children's responses, the results suggest that in order to get a more complete idea of children's use of technologies, the best way forward is to combine their self-reported data with usage data. It should be stressed here that these results should not be taken as a reason for not using self-report data by children in future research, but they should be used in combination with actual usage data. There are many reasons why children should be directly asked about their own experiences, as they are the ones who know their actions and beliefs better than anyone else, they have the right to talk for themselves, the design of the self-report tools can add to the accuracy of the data and previous research has supported a clear-rationale for its use (Sturgess, Rodger & Ozanne, 2002).

7.4 Limitations

There are two main limitations of this thesis that need to be discussed. The first one refers to the fact that the results are based on correlations, and the second one is that the data were collected from schools in the South West of England and they cannot be generalised to the rest of the UK.

The first of the limitations of the thesis is that three out of the four studies are based on correlations. Correlations are useful in identifying links between the variables in question and they can be the starting point of a deeper understanding of a situation and further research, but they do not equal causation and they do not show the direction of the relationship between the variables. In terms of the results of the thesis, this means that it was proved that some of the relationships between the different factors of digital experiences, the ways children use online maths websites and their performance on them are significant, but the direction of those relationships remains unclear. For example, although one of the results showed that the children's maths performance is positively linked to their computer skills, it cannot be argued that higher computer skills cause higher online maths performance, or that higher maths performance causes higher computer skills. For that reason, the results should be taken with caution. In addition to that, the majority of the significant correlations between the measures of the studies were medium or low.

It should also be mentioned that the schools who participated in the studies of this thesis were all from the areas of Bristol and Bath, South West of England, and they cannot be generalised to the rest of the UK. It could be argued that both areas are considered affluent and they do not represent the complexity and variation of students' backgrounds that other areas have. For example, the researcher examined the percentages of children that are eligible for free meals in each of the four schools that took part in the studies of the thesis and found that all of them were under the average percentage in the UK (13.7% for primary schools).

7.5 Implications

The thesis fills some of the gaps of the existing literature in relation to children's digital experiences and their use and performance on online maths websites by using a combination of self-report and usage data. Previous research has mainly focused on the use of technologies at the level of secondary and higher education leaving the years of primary unexplored. However, current developments in the ways that children are assessed in primary schools and the introduction of on-screen multiplication tests make this research topical.

It is really important that any changes and reforms that happen in the Educational sector by the Department of Education need to be advised and guided by current research. Although changes such as the implementation of technologies in summative assessment might seem the right way forward and they could be considered pioneering, it is essential to make sure that all students will be equally prepared for those changes and there will be no inequalities or differences based on their previous digital experiences.

As Kennedy et al. (2008) and Jones and Shao (2011) have argued, in order for policies to be appropriate for all students, a clearer understanding of how children use technologies is needed. The results of the thesis showed that there is a great variation of technological skills amongst students which are related to their digital experiences at home. Thus, it could be argued that students who have richer digital experiences at home might also have an extra advantage on the online assessments, which would be unfair for those students who do not have the same broad digital experiences. Teachers need to make sure that the digital experiences they offer at school complement any possible difficulties or poverty that the children might face at home. This dynamic is also illustrated and supported by the two parallel systems of home and school model which was discussed above.

7.5.1 Implications for applied settings

Apart from raising awareness about children's technological skills to policy makers and people working at the DfE, the thesis also offers some more practical implications for school settings. More specifically, one way that the findings of this thesis can be applied in classrooms is the use of the first part of the questionnaire, which was used in studies 2 and 3 as a measure for children's digital experiences at home. Teachers can use this questionnaire in order to identify the digital devices their pupils have access to, how they use these devices, and what their pupils' technological skills are. In that way, teachers can adjust their planning and teaching based on each child's digital experiences rather than their own assumptions for children's background and skills. The teachers who will use this questionnaire will avoid taking their students' technological skills for granted and will be able to offer instant technological help and guidance to the children who need it the most in a discreet way, without having to ask children about their ownership or digital skills in the classroom. The results of this questionnaire can also help the school identify whether an after school club for online maths homework or technological skills is necessary, based on the number of the students who have or do not have access to technology at home.

In addition to that, and based on the fact that children's confidence, confounded with frequency, was found to be a key predictor of children's engagement with the online maths websites (the more children engage with technology, the more confident they are with technology the more they engage with the maths websites), teachers can also work on building children's engagement with technology in order to make them more confident users of technology. In that way, they will be able to assist children with their engagement with the maths websites and thus, their maths skills. The measures of confidence and computer skills were linked to children's performance on OMWs, so when teachers aim to build on pupils' engagement with technology, they also assist them with their online homework performance and assessments like the MCT. Teachers can help with children's engagement with technology by starting interventions that will encourage children to use technologies in a variety of ways and different projects. For example, each school could have their own after school club or group initiative of encouraging children to use technologies in creative, imaginative ways, e.g. using different digital technologies and skills to create a children's book about the different ways that knowing your times-tables can help you in everyday life. Different groups of children can use different digital devices and work on various software in order to accomplish their aim. An initiative like that could help children engage with technology and build their breadth of uses, together with their confidence and computer skills.

The Online Maths Websites, like Mathletics, could also use the finding in relation to confidence in order to find ways to develop children's confidence through their online tasks. One such way could be using the Avatars on the website to offer messages of support and encouragement during the students' tasks. It would be also good if the avatars in addition of the comments they make to the children's instant answers, they could also comment on the general progress of the child combining older data and answers that the child has given in the past with new answers. For example, "*Well done! You have made great improvement on this topic and your score has raised by 20 points since last week! Would you like to try something more challenging now?*".

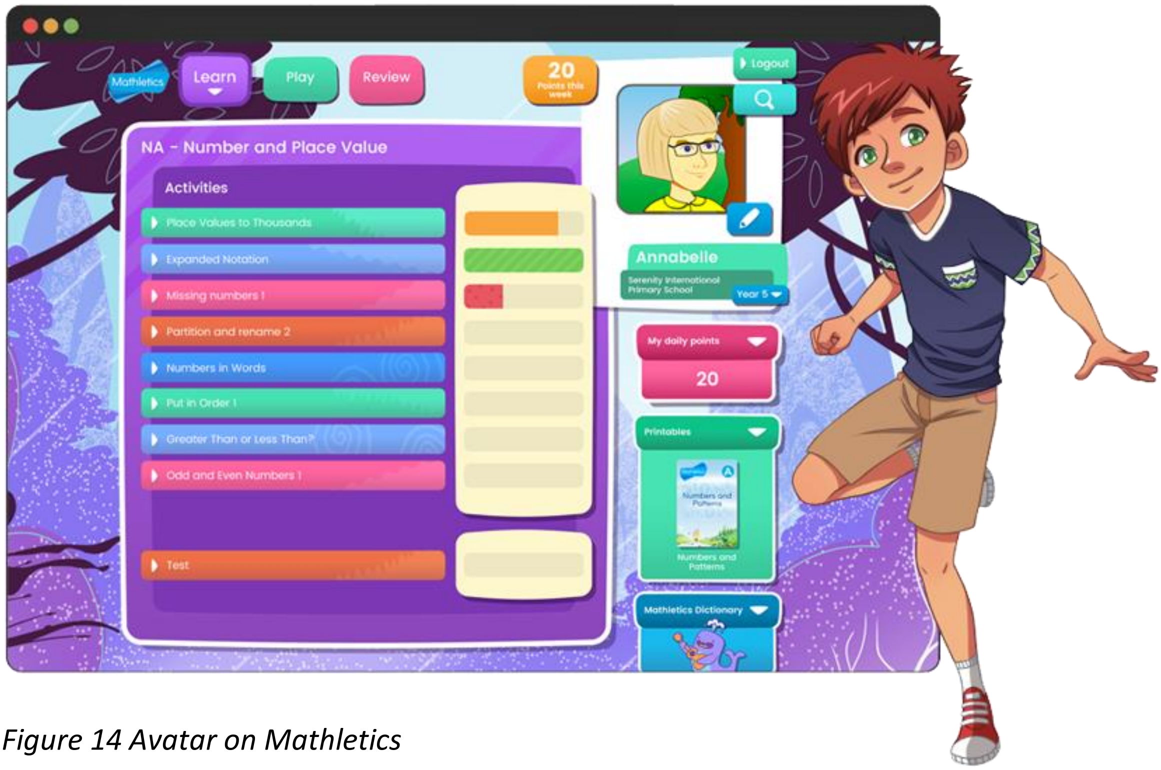

Figure 14 Avatar on Mathletics

Figure 14 shows an example of how a Mathletics avatar looks and the layout of the website. Previous work on avatars as virtual learning companions has suggested that they can contribute significantly to students' learning experiences, motivation and engagement (Falloon, 2010; Girvan & Savage, 2019; Hsu, Chou, Chen, Wang, & Chan, 2007; Lester, Zettlemoyer, Grégoire, & Bares, 1999; Luckin, Holmes, Griffiths, & Forcier, 2016). Mathletics and all similar websites collect an enormous amount of data from each student every time they use the website and usually the parents and the teachers are the ones who have access to all or some of this data, so they can use this information not only for future teaching and planning, but also to inform their interventions.

Finally, online maths websites, but also schools, can invest and focus on how to provide more training to their teachers. As it was shown in study 4, the more training teachers have, the more likely they are to use a wide range of different functions of the online maths websites. In that way, teachers will be able to use their digital resources in the most efficient ways for their students.

7.6 Future Work

The thesis has brought out a number of interesting paths for future research in terms of the new online compulsory assessment, the system of home/parents, comparative research across different countries and further investigation into the similarities and differences between digital native and immigrant teachers in longitudinal studies.

In order to change the educational system, the curriculum and the assessments in primary schools in relation to children's technological skills, it would be interesting to investigate whether teachers' beliefs of children's technological skills match the actual technological skills of children. A very recent similar study explored this with children aged 3-5 years old and found that actually the children could complete 9 out of 12 iPad tasks without any help, while the teachers thought that the children would need assistance more often than that (Mourlam, Strouse, Newland & Lin 2019). In general, teachers both over- and under- estimated the children's skills in half of the tasks the children completed. This is an interesting finding, which shows that making assumptions about children's technological skills can lead teachers to wrong decisions in relation to ICT use in the classroom. Thus, conducting more research on the actual technological skills that children have when they start primary school will offer a better understanding of how technology can be implemented in education practice.

Another interesting project for future research would be to further investigate how the factor of home influences the digital experiences of children. Especially since the thesis suggests that the digital experiences of children at home are linked to their actual maths performance, it would be important to investigate further how parents and the system of home affect children's performance. Previous research on the relationship between home and school technologies has shown that the family is an important factor in the design of technologies that are used at home and it should not be ignored (Fraser, Rodden & O'Malley, 2006).

There is previous research that indicates that confidence in maths and achievement are positively linked (Ganley & Vasilyeva, 2011; Ganley & Lubienski, 2016; Liu, 2009; Valentine et al. 2004). However, the direction of this relationship is not clear with some researchers arguing for a self-enhancement model which supports the idea that confidence impacts achievement, others arguing for a skill development model, where maths achievement improves confidence, while most of the researchers working in this area support a reciprocal model (Ganley & Lubienski, 2016). Further research can also focus on whether the relationship between confidence in using technology and online maths performance is following any of the three models above.

More specifically, the fact that children's confidence was linked to frequency, breadth, computer skills in both studies 2 and 3 suggests that it is an important factor that could be explored further in order to examine the direction of these positive relationships. Since the findings are correlational and not causational, the direction of the relationships is unknown. However, if future research focuses on exploring whether, for example, confidence on the use of technologies causes the development of better computer skills, or better computer skills cause more confidence, then this could inform future learning environments.

Another interesting area of future work would be to investigate whether interventions like the ones mentioned in the implications section can actually enhance children's engagement with technology and thus their confidence and computer skills. If these interventions are proved successful, then the details and information of these interventions can be shared as good-practice to other schools and the benefit to children can be maximised. Outhwaite, Gulliford and Pitchford (2017) assessed a tablet-technology maths intervention in early primary school and found strong and sustained benefits for the students, which makes similar interventions worth researching and promising.

Lastly, researchers could conduct longitudinal research on the area of children's use of technologies and their maths performance in order to be able to identify the direction of their relationship and have a more complete understanding of how the skills of children develop throughout the years.

7.7 Overall conclusion

The thesis has offered a greater understanding of children's and teachers' digital experiences and their use of Online Maths Websites through the theoretical frameworks of the Educational Digital Divide and the concept of Digital Natives and Immigrants in primary schools. The findings of the thesis agree with previous research in relation to the fact that there is no unique generation of children and students who all acquire the same technological skills based on their birth year. It was found that the confidence with which children use technologies was one of the factors that appeared to be linked to the ways that children use the online maths websites and their performance on their websites in both studies and it is a factor that has not been discussed in depth in previous research. It could be argued that this finding could be the starting point for more research on the topic, especially in relation to the direction of these relationships that could lead to the development of future learning and confidence interventions. The thesis has also raised some questions in relation to the validity of self-report data. The fact that the self-report data from the children and the usage data from the website's archive were linked with weak correlations shows that self-report data should be taken and interpreted with caution. It could be argued that the best way forward for future research should be a combination of both self-report and usage data in order the researchers to have a better understanding of the topic they explore. It is worth mentioning that change and progress in relation to education are important and the educational systems should not be left behind in the technological developments of the current years. However, all changes, especially the ones that are focused on educational assessment should be well thought, organised, advised and guided by research and evidence in order to be successful for both the teachers and the children.

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Appendices

Appendix A: Interview Procedure and Questions for Students and Teachers (Study 1)

1. Students

Thank you very much for taking part in my study.

Explain to them the purpose of the interview (as a short briefing and reminder of the information sheet)

Your help is very important to me.

Confidentiality of responses is guaranteed.

Approximate length of interview: 30 minutes

Format of interview; 3 main parts

- Technology
- Assessment
- 2 activities for technology in assessment
    - Images about students' psychology and performance
    - Role play about subjects and technology

Remind them that they could withdraw at any time without any consequences

Tell them how to get in touch with me later if they want to

Ask them if they have any questions before get started with the interview

1. <u>Technologies in the classroom (5 mins)</u>

1. What kind of technologies do you use in school? For what reason?
2. What do you like the most and the least about these technologies?
3. What kind of educational games do you play, in or out of schools?

2. <u>Assessment in the classroom (5 mins)</u>

4. What are your first thoughts when you hear about exams and tests? Why? (For example, you have an English or a maths lesson and your teachers says that on Friday, you will take a test. What do you think when you hear that?)
5. How you are usually assessed? (Handwritten tests? Oral questions?)
6. What do you usually do the day before an exam/test?
7. How often are these tests/exams?
8. What is the best and worst part of assessment at school?
9. Why do you think you are assessed (Is it important to check if we remember what we have learnt)?

3. <u>Technologies in assessment (20 mins)</u>

Activity 1

I will introduce the images of the handwritten test (image 1) and the assessment in situ (image 2).

1. What do you think those students are doing in each situation?
2. Would either image change what you said before about exams and tests? Why?
   2.1 What about your interest regarding the test?
   2.2 How would you feel in each situation?
   2.3 Which one seems easier and which one more difficult?
3. If it was a geography test for example, which test would you like to take?
4. Have you ever used any technology to take an exam/test at school?

Activity 2

I will give them the glasses and will tell them:

"Now I would like you to use your imagination, become a teacher yourself and think how you would assess one of the units you are taught. You can think of your classmates and even yourself, as your own students."

5. Which of the subjects you are taught in your class, do you think could be assessed using a technology like a tablet, or a computer?
6. Which of these two ways would you choose?
7. So, if I could give you a tablet or a mobile phone and ask you to use it to assess a unit, how would you do that?
8. Would you set the assessment activity outside or inside of the classroom?
9. Would you ask the students to take the exam in pairs/groups or individually?

<u>Closing:</u>

1. If you could choose only one unit to be assessed using a technology, which one would that be and with what kind of technology?
2. Do you have any other experiences with technology in a learning context that you would like to share with me or something that I didn't ask you and you would like to add?

- ✓ Thank them again and offer them their present.

2. Teachers

Thank you very much for taking part in my study.

Explain to them the purpose of the interview (as a short briefing and reminder of the information sheet)

I believe your input will be valuable to this research.

Confidentiality of responses is guaranteed.

Approximate length of interview: 30 minutes

Format of interview; 3 main parts

- Technology
- Assessment
- Technology in assessment
  - Potential uses
  - Students' psychology and performance regarding that

Remind them that they could withdraw at any time without any consequences

Tell them how to get in touch with me later if they want to

Ask them if they have any questions before get started with the interview

1. **<u>Technologies in the classroom (5 mins)</u>**
2. What kind of technological tools do you have in your classroom? (access to technologies in general)
3. For what purposes do you use those technologies?
   (For example, did you use any kind of technology the past week? For what purpose?)
4. What motivated you to use that technology?
5. Sometimes teachers argue that they don't use the technology equipment that the school has, because of lack of training, or support. What is your opinion on that?

3. **<u>Assessment in the classroom (5 mins)</u>**

    1. Are there any specific guidelines on how the students should be assessed, or you are free to develop your own assessment activities?
    2. Which are the main assessment techniques you prefer to use? Why?

    (For example, the technique that was used the last time students were assessed)

    3. How different are the techniques for formative and summative assessment?
    4. How regularly are the students assessed?

4. **<u>Technologies in assessment (20 mins)</u>**

    1. Do you use any of the technologies you mentioned earlier in assessment activities, or for assessment purposes (like e-portfolios)?
    2. If yes, in which ways? In your opinion, what technologies have to offer to assessment? (Pros and cons)
    3. If not, why not? How do you think technologies could be used in assessment? (pros and cons)
    4. If you had all the required equipment, any technological tool that you would like, which subject/s would you choose to assess with it, and which tool would that be? How would you use it?
    5. What is the relationship of your students with new technologies?
    6. You know your students better than anyone else. Do you know if the integration of technology into assessment could influence students' feelings about tests and exams? In what way?
    7. What about their interest in the activity?
    8. What about their performances? Do you think that if they would feel differently for the test their performance could change as well?
    9. Regarding on screen assessment, would that make any difference to your students if they would take the same test that the usually take on paper, on screen?
    10. How easy do you think it is for students to apply their knowledge in a real context situation like during a field trip or a visit at a museum?

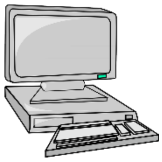
11. Would you assess a history unit, for example, during a field trip? In a museum?
12. Which, do you think, are the units that are more appropriate to be assessed in a real context situation?

Closing:

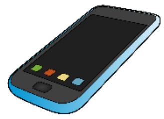
1. If a friend teacher would ask you to tell him/her your most favourable technique for assessing your students, which one would it be and why?
2. If he/she asked you about the most useful technological tool you have used in your classroom, which one would it be and why?
3. Do you have any other experiences with technology in a learning context that you would like to share with me or something that I didn't ask you and you would like to add?

- ✓ Thank them again and offer them their treat!

Appendix B: Questionnaire for Pupils (Study 2)



<u>Digital Experiences and Online Maths Websites</u>



This is a **private** questionnaire and your answers will be viewed only by the researcher and no one else. The questionnaire has 2 parts. The 1st part asks you about your use of technologies and the Internet and the 2nd part asks you about the online maths website you use at school and home. This is not a test and there are no right or wrong answers.

<u>Please fill in all the questions.</u>

<u>About you</u>

1. Participant Number

____

2. School Year and Age:

_______________________ _______________________

3. Name of the Online Maths Website you use at school and home

____

4. Gender: (please circle one)

Boy Girl

<u>Part 1: Digital Experiences</u>

5. Do you have access to a <u>computer</u> at home?

Yes No

If **YES**,

a) How many hours do you spend on the computer in a day at home? (circle one)

None 1 hour 2 hours` 3 hours Over 3 hours

b) How many days did you use the computer at home in the last week? (circle one)

None Once a week Several Times a week Every day

6. Do you have access to a <u>tablet</u> at home?

Yes No

If **YES,**

a) How many hours do you spend on the tablet in a day at home? (circle one)

None 1 hour 2 hours` 3 hours Over 3 hours

b) How many days did you use the tablet at home the last week? (circle one)

None Once a week Several Times a week Every day

7. Do you have access to a <u>laptop</u> at home?

Yes No

If **YES,**

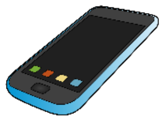
a) How many hours do you spend on the laptop in a day at home? (circle one)

None 1 hour 2 hours` 3 hours Over 3 hours

b) How many days did you use the laptop at home the last week? (circle one)

None Once a week Several Times a week Every day

8. Do you have access to a <u>mobile phone</u> at home?



Yes No

If **YES,**

a) How many hours do you spend on the mobile phone in a day at home? (circle one)

None 1 hour 2 hours` 3 hours Over 3 hours

b) How many days did you use the mobile phone at home the last week? (circle one)

None Once a week Several Times a week Every day

9. Do you have access to a <u>game console</u> at home?

Yes No

If **YES,**

a) How many hours do you spend on the game console in a day at home? (circle one)

None 1 hour 2 hours` 3 hours Over 3 hours

b) How many days did you use the game console at home the last week? (circle one)

None Once a week Several Times a week Every day

10. Do you have access to a <u>TV</u> at home?

Yes No

If **YES,**

a) How many hours do you spend on the TV in a day at home? (circle one)

None 1 hour 2 hours` 3 hours Over 3 hours

b) How many days did you use the TV at home the last week? (circle one)

None Once a week Several Times a week Every day

11. Do your parents have rules for how long you can use the computer/tablet/laptop/TV? (circle one)

Yes No

If **YES,**

a) How many hours are you allowed to use the computer/tablet/laptop/TV in a typical day? (write a number)

Hours for computer/tablet/laptop: _______________
Hours for TV: _______________

12. Do you have access to the <u>Internet</u> at home?

Yes No

If **YES,**

a) What do you use the Internet for? (you can circle more than one)

Schoolwork Games Communicate with Friends Fun Other ___________

13. When do you use your computer/tablet/laptop? (you can circle more than one)

Before school After school Weekday nights Weekends

14. Your computer skills are: (circle one)

Poor Good Very Good Excellent

15. Have you ever shown your parents how to use the computer/tablet/laptop? (circle one)

Never Sometimes Quite Often Always

16. Do you need help from your teacher or classmates on how to work on the computer? (circle one)

Never Sometimes Quite Often Always

17. How often do you use your computer/tablet/laptop to: (tick one box for each choice)

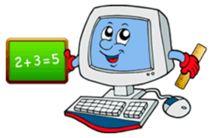
	Never	Less than once a week	Once a week	Several times a week	Once a day	Several times a day
Chat online (talk with friends)						
Play Games						
Surf the web for fun						

	Never	Less than once a week	Once a week	Several times a week	Once a day	Several times a day
Surf the web for Schoolwork/ Search information						
Go on YouTube						
Do your Maths homework						
Do other subjects' homework						
Use the School's website						
Use Word						
Create a video						
Use Power Point						
Listen to music						
Do some coding						
Collaborate with classmates on a school project						

18. How confident do you feel when you have to: (tick one box for each choice)

	 Not Confident (I have no idea-even with help I cannot do it)	 A bit confident (I understand a little-with help I can do some of it)	 Not sure (I can do most of it-I still need help sometimes)	 Confident (I can definitely do it)	 Very confident (I could even teach that to others)
Download files (e.g. Pictures, Games, Music, Videos, animation, text software)					
Save files in specific folders					
Create folders					
Type fast					
Print					
Use the camera of the device					
Be safe online					
Use Word					
Use Power Point					
Copy and paste text					
Move files to different folders					
Use a USB stick					
Use text, photo, sound and video editing tools					
Assess the information from the Internet					
Share your ideas online					
Use the spellchecker					

Part 2: Online Maths Website



1. How often do you do your online Maths homework at home? (circle one)

Never   Sometimes   Quite Often   Always

2. How often do you do your online Maths homework at school, or at the After School Club? (circle one)

Never   Sometimes   Quite Often   Always

3. How many hours in average do you spend doing the online homework? (write a number)

____

4. How often do you take the practice lessons that the website provides? (circle one)

Never   Sometimes   Quite Often   Always

5. How many times do you try each Maths task depending on the score you get?

Once   Twice   Until I get the grade I want

6. How confident do you feel in Maths? (circle one)

Not Confident   A bit confident   Not sure   Confident   Very confident

7. How confident do you feel in using the Maths website to do your homework?

Not Confident   A bit confident   Not sure   Confident   Very confident

8. How often does your Mum help you when you do your online maths homework?

Never   Sometimes   Quite Often   Always

9. How often does your Dad help you when you do your online maths homework?

Never   Sometimes   Quite Often   Always

10. How often does your brother/sister help you when you do your online maths homework? (circle one)

Never   Sometimes   Quite Often   Always

11. How often does a friend help you when you do your online maths homework?

Never   Sometimes   Quite Often   Always

12. Does the teacher set specific tasks for homework, or do you choose what tasks to do?

The teacher Me Both

13. How many problems or tasks do you usually get right? (circle one)

A few Some Many All

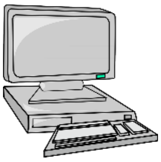
14. Please rate the following choices: (tick one box for each choice)

	Strongly disagree	Disagree	Not sure	Agree	Strongly Agree
I enjoy doing my homework on the computer					
I find the homework on the online website easy					
I know how to use the online maths website very well					
I use paper and pen for my workings when I do my homework online					
I prefer to do the homework on my notebook					

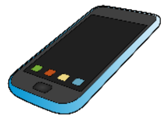
Thank you!!

Appendix C: Questionnaire for Pupils (Study 3)

<u>Digital Experiences and Mathletics</u>



This is a **private** questionnaire and your answers will be viewed only by the researcher and no one else. The questionnaire has 2 parts. The 1st part asks you about your use of technologies and the Internet and the 2nd part asks you about how you use Mathletics at school and home. This is not a test and there are no right or wrong answers.



<u>Please fill in all the questions.</u>

Date: ________________________

<u>About you</u>

1. Mathletics login username (for example: ES-45715)

____

2. School Year and Age:

Year 3 Year 4 Year 5 Year 6 **<u>AND</u>** 7 years old 8 y/o 9 y/o 10 y/o 11 y/o

3. Gender: (please circle one)

Boy Girl

<u>Part 1: Digital Experiences</u>

1. Do you have access to a desktop <u>computer</u> at home?

Yes No

If **YES,**

c) How long do you spend on the computer on a **<u>weekday</u>** at home? (circle one)

None 15 minutes 30 minutes 1 hour 2 hours` 3 hours Over 3 hours

b) How long do you spend on the computer during the **<u>weekend</u>** at home? (circle one)

None 15 minutes 30 minutes 1 hour 2 hours` 3 hours Over 3 hours

c) How many times did you use the computer at home in the **<u>last week</u>**? (circle one)

None Once a week Several Times a week Every day

2. Do you have access to a <u>tablet</u> at home?

Yes No

If **YES,**

d) How long do you spend on the tablet on a **<u>weekday</u>** at home? (circle one)

None 15 minutes 30 minutes 1 hour 2 hours` 3 hours Over 3 hours

b) How long do you spend on the tablet during the **<u>weekend</u>** at home? (circle one)

None 15 minutes 30 minutes 1 hour 2 hours` 3 hours Over 3 hours

c) How many times did you use the tablet at home in the **<u>last week</u>**? (circle one)

None Once a week Several Times a week Every day

3. Do you have access to a <u>laptop</u> at home?

Yes No

If **YES,**

e) How long do you spend on the laptop on a **<u>weekday</u>** at home? (circle one)

None 15 minutes 30 minutes 1 hour 2 hours 3 hours Over 3 hours

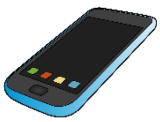
b) How long do you spend on the laptop during the **<u>weekend</u>** at home? (circle one)

None 15 minutes 30 minutes 1 hour 2 hours 3 hours Over 3 hours

c) How many times did you use the laptop at home in the **<u>last week</u>**? (circle one)

None Once a week Several Times a week Every day

4. Do you have access to a <u>mobile phone</u> at home?



Yes No

If **YES,**

f) How long do you spend on the mobile phone on a **<u>weekday</u>** at home? (circle one)

None 15 minutes 30 minutes 1 hour 2 hours` 3 hours Over 3 hours

b) How long do you spend on the mobile phone during the **<u>weekend</u>** at home? (circle one)

None 15 minutes 30 minutes 1 hour 2 hours` 3 hours Over 3 hours

c) How many times did you use the mobile phone at home in the **<u>last week</u>**? (circle one)

None Once a week Several Times a week Every day

9. Do you have access to a <u>game console</u> at home?

Yes No

If **YES,**

a) How long do you spend on the game console on a **<u>weekday</u>** at home? (circle one)

None 15 minutes 30 minutes 1 hour 2 hours` 3 hours Over 3 hours

b) How long do you spend on the game console during the **<u>weekend</u>** at home? (circle one)

None 15 minutes 30 minutes 1 hour 2 hours` 3 hours Over 3 hours

c) How many times did you use the game console at home in the **<u>last week</u>**? (circle one)

None Once a week Several Times a week Every day

10. Do you have access to one or more of the following devices at home? (circle one or more)

Arduino   Raspberry Pi   Makey-Makey   Micro:bit   Other ________   None

If **YES,**

a) How long do you spend on one or more of these devices on a **<u>weekday</u>** at home? (circle one)

None   15 minutes   30 minutes   1 hour   2 hours`   3 hours   Over 3 hours

b) How long do you spend on one or more of these devices during the **<u>weekend</u>** at home? (circle one)

None   15 minutes   30 minutes   1 hour   2 hours`   3 hours   Over 3 hours

c) How many times did you use one or more of these devices at home in the **<u>last week</u>**? (circle one)

None   Once a week   Several Times a week   Every day

11. Do you have access to the <u>Internet</u> at home?

Yes   No

If **YES,**

a) What do you use the Internet for? (you can circle more than one)

Schoolwork   Games   Communicate with Friends   Fun   Other ____________

12. Your computer skills are: (circle one)

Poor   Good   Very Good   Excellent

13. Have you ever shown your parents how to use the computer/tablet/laptop? (circle one)

Never   Sometimes   Quite Often   Always

14. Do you need help from your teacher or classmates on how to work on the computer? (circle one)

Never Sometimes Quite Often Always

15. How often do you use your computer/tablet/laptop to: (tick one box for each choice)

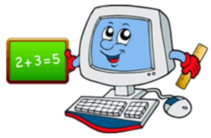
	Never	Less than once a week	Once a week	Several times a week	Once a day	Several times a day
Chat online (talk with friends)						
Play Games						
Surf the web for fun						
Surf the web for Schoolwork/ Search information						
Go on YouTube						
Do your Maths homework						
Do other subjects' homework						
Use the School's website						
Use Word						
Create a video						
Use Power Point						
Listen to music						
Do some coding						
Collaborate with classmates on a school project						

16. How confident do you feel when you have to: (tick one box for each choice)

	 Not Confident (I have no idea-even with help I cannot do it)	 A bit confident (I understand a little-with help I can do some of it)	 Not sure (I can do most of it-I still need help sometimes)	 Confident (I can definitely do it)	 Very confident (I could even teach that to others)
Download files (e.g. Pictures, Games, Music, Videos, animation, text software)					
Save files in specific folders					
Create folders					
Type fast					
Print					
Use the camera of the device					
Be safe online					
Use Word					
Use Power Point					
Copy and paste text					
Move files to different folders					
Use a USB stick					
Use text, photo, sound and video editing tools					
Assess the information from the Internet					

Share your ideas online					
Use the spellchecker					

<u>Part 2: Mathletics</u>



1. How often do you do your Mathletics homework <u>at home</u>? (circle one)

Never   Sometimes   Quite Often   Always

2. How often do you do your Mathletics homework <u>at school</u>, or at the <u>After School Club</u>? (circle one)

Never   Sometimes   Quite Often   Always

3. How long on average do you spend on your Mathletics homework in a typical day? (circle one)

0-10 minutes	11-20 minutes	21-30 minutes	31-40 minutes	41-50 minutes	51-60 minutes	More than 1 hour	Other (more/less): ______________

4. How many times do you try each Maths task depending on the score you get?

Once   Twice   Until I get the grade I want

5. How confident do you feel in Maths? (circle one)

Not Confident   A bit confident   Not sure   Confident   Very confident

6. How confident do you feel in using Mathletics to do your homework?

Not Confident   A bit confident   Not sure   Confident   Very confident

7. How many problems or tasks do you usually get right? (circle one)

A few   Some   Many   All

8. Has Mathletics improved your confidence in Maths?

Not at All   Not Really   I don't know   Somewhat   Very Much

9. Has Mathletics helped you understand topics you had difficulties with?

Yes   No

If **YES,**

a) Which topics were these?

____

10. Has Mathletics helped you become better at Maths?

Not at All   Not Really   I don't know   Somewhat   Very Much

11. Do you spend more time doing Maths since you started using Mathletics?

Yes   No

12. Which one do you enjoy more?

Mathletics in the <u>classroom</u>   Mathletics at <u>home</u>   Both

13. Please rate the following choices: (tick one box for each choice)

	Strongly disagree 	Disagree 	Not sure 	Agree 	Strongly Agree 
I enjoy doing my Mathletics homework					
I find the homework on Mathletics challenging					
I enjoy maths more since using Mathletics					
I know how to use Mathletics very well					
I use paper and pen for my workings when I do my Mathletics homework online					
I prefer to do My Maths homework in my notebook					
I believe I can improve even more at Maths					
I believe when I practice my Maths I become better.					
Everybody can improve their maths ability					

Appendix D: Questionnaire for Teachers as created in Word by the Qualtrics Survey Software (Study 4)

The Digital Experiences of Teachers in Primary School and the use of Online Maths Websites

Q1 Study information for Teachers of Primary Schools who use Online Maths Websites

If you are a Teacher who is working in a Primary School and you use any kind of Online Maths Websites, such as Abacus, Mathletics, My Maths, or another similar website, with your students, then we would like to invite you to take part in the following study about Teachers' use of technologies at home and the use of Online Maths Websites. By taking part in the study, you can also enter into a £50 cash prize draw after the completion of the survey.

What does the study include and how long will it take?

The study includes the following online questionnaire which involves questions about how you use technologies at home and how you use Online Maths Websites. The questionnaire takes only 5-10 minutes. Please note, that this is not an assessment of technology or Online Maths Websites use, but an effort to gain a better understanding of how teachers with different digital experiences use these kind of websites. Participation in this research is voluntary and you are free to withdraw from the study, at any time and without any consequences. This research has been reviewed and passed by the University of Bath Psychology Ethics Committee, it meets their ethical guidelines and poses no risk to participants.

What happens to the answers?

The information from the questionnaires will be kept strictly confidential and the research will protect your anonymity. If you decide to leave your email at the end of the questionnaire, this will only be used for the draw of the £50. Who can you ask for further information about the study? If you would like to take part in this study and you want any more information, or have questions, please do not hesitate to contact: Eleni Anna Skoulikari, email: eaas20@bath.ac.uk

The questionnaire is completed, now?

The draw will take place as soon as the data collection finishes and if you have won, then you will be informed via your email.

Q2 Consent

I have read and understood the information about this study. I understand that participation in this study is voluntary and I can withdraw from it without any consequences at any time. I understand who will have access to the collected data from the questionnaire, and I am aware that the research has been approved by the University's Ethics Committee.

I consent that I want to complete the questionnaire and that the researcher can use anonymised quotes from the questionnaire.

I consent that the anonymised collected data from this research can be used by the researcher for publications in academic journals and conferences and for subsequent analysis at a later date. I can confirm that I am willing to take part in this research.

- Yes (1)
- No (2)

If No Is Selected, Then Skip To End of Survey

Q3 Gender

- Male (1)
- Female (2)

Q4 Age

- 20-30 (1)
- 31-40 (2)
- 41-50 (3)
- 51-60 (4)
- 61+ (5)

Q5 City/town you are working

- London (1)
- Bristol (2)
- Bath (3)
- Birmingham (4)
- Leeds (5)
- Liverpool (6)
- Sheffield (7)
- Manchester (8)
- Edinburgh (9)
- Glasgow (10)
- Other (please specify) (11) ____________________

Q6 Which of the following Online Maths Websites do you use at school?

- Abacus (1)
- Mathletics (2)
- Maths Zone (3)
- My Maths (4)
- Interactive Resources (5)
- Other (please specify) (6) ____________________

Q7 How long have you been using the above mentioned Online Maths Website/s?

- Some months (1)
- 1 year (2)
- 2 years (3)
- 3 years (4)
- 4 years (5)
- more than 4 years (6)

Q8 Which are the Year groups you are using the Online Maths Websites for?

- Year 1 (1)
- Year 2 (2)
- Year 3 (3)
- Year 4 (4)
- Year 5 (5)
- Year 6 (6)

Q9 Do you have access to a desktop computer at home?

- Yes (1)
- No (2)

Q10 How long do you spend on the computer on a weekday at home?

- None (1)
- 15 minutes (2)
- 30 minutes (3)
- 1 hour (4)
- 2 hours (5)
- 3 hours (6)
- 4 hours (7)
- 5 hours (8)
- Over 5 hours (9)

Q11 How long do you spend on the computer during the weekend at home?

- None (1)
- 15 minutes (2)
- 30 minutes (3)
- 1 hour (4)
- 2 hours (5)
- 3 hours (6)
- 4 hours (7)
- 5 hours (8)
- Over 5 hours (9)

Q12 How many times did you use the computer at home in the last week?

- None (1)
- Once a week (2)
- Several times a week (3)
- Every day (4)

Q13 Do you have access to a tablet at home?

- Yes (1)
- No (2)

Q14 How long do you spend on the tablet on a weekday at home?

- None (1)
- 15 minutes (2)
- 30 minutes (3)
- 1 hour (4)
- 2 hours (5)
- 3 hours (6)
- 4 hours (7)
- 5 hours (8)
- Over 5 hours (9)

Q15 How long do you spend on the tablet during the weekend at home?

- None (1)
- 15 minutes (2)
- 30 minutes (3)
- 1 hour (4)
- 2 hours (5)
- 3 hours (6)
- 4 hours (7)
- 5 hours (8)
- Over 5 hours (9)

Q16 How many times did you use the tablet at home in the last week?

- None (1)
- Once a week (2)
- Several times a week (3)
- Every day (4)

Q17 Do you have access to a laptop at home?

- Yes (1)
- No (2)

Q18 How long do you spend on the laptop on a weekday at home?

- None (1)
- 15 minutes (2)
- 30 minutes (3)
- 1 hour (4)
- 2 hours (5)
- 3 hours (6)
- 4 hours (7)
- 5 hours (8)
- Over 5 hours (9)

Q19 How long do you spend on the laptop during the weekend at home?

- None (1)
- 15 minutes (2)
- 30 minutes (3)
- 1 hour (4)
- 2 hours (5)
- 3 hours (6)
- 4 hours (7)
- 5 hours (8)
- Over 5 hours (9)

Q20 How many times did you use the laptop at home in the last week?

- None (1)
- Once a week (2)
- Several times a week (3)
- Every day (4)

Q21 Do you have access to a mobile phone?

- Yes (1)
- No (2)

Q22 How long do you spend on the mobile phone on a weekday?

- None (1)
- 15 minutes (2)
- 30 minutes (3)
- 1 hour (4)
- 2 hours (5)
- 3 hours (6)
- 4 hours (7)
- 5 hours (8)
- Over 5 hours (9)

Q23 How long do you spend on the mobile phone during the weekend?

- None (1)
- 15 minutes (2)
- 30 minutes (3)
- 1 hour (4)
- 2 hours (5)
- 3 hours (6)
- 4 hours (7)
- 5 hours (8)
- Over 5 hours (9)

Q24 How many times did you use the mobile phone in the last week?

- None (1)
- Once a week (2)
- Several times a week (3)
- Every day (4)

Q25 Do you have access to a game console at home?

- Yes (1)
- No (2)

Q26 How long do you spend on the game console on a weekday at home?

- None (1)
- 15 minutes (2)
- 30 minutes (3)
- 1 hour (4)
- 2 hours (5)
- 3 hours (6)
- 4 hours (7)
- 5 hours (8)
- Over 5 hours (9)

Q27 How long do you spend on the game console during the weekend at home?

- None (1)
- 15 minutes (2)
- 30 minutes (3)
- 1 hour (4)
- 2 hours (5)
- 3 hours (6)
- 4 hours (7)
- 5 hours (8)
- Over 5 hours (9)

Q28 How many times did you use the game console at home in the last week?

- None (1)
- Once a week (2)
- Several times a week (3)
- Every day (4)

Q29 Do you have access to one or more of the following devices at home?

- Arduino (1)
- Raspberry Pi (2)
- Makey-Makey (3)
- Micro:bit (4)
- Other (please specify) (5) ____________________
- None (6)

Q30 How long do you spend on one or more of these devices on a weekday at home?

- None (1)
- 15 minutes (2)
- 30 minutes (3)
- 1 hour (4)
- 2 hours (5)
- 3 hours (6)
- 4 hours (7)
- 5 hours (8)
- Over 5 hours (9)

Q31 How long do you spend on one or more of these devices during the weekend at home?

- None (1)
- 15 minutes (2)
- 30 minutes (3)
- 1 hour (4)
- 2 hours (5)
- 3 hours (6)
- 4 hours (7)
- 5 hours (8)
- Over 5 hours (9)

Q32 How many times did you use one or more of these devices at home in the last week?

- None (1)
- Once a week (2)
- Several times a week (3)
- Every day (4)

Q33 Do you have access to the Internet at home?

- Yes (1)
- No (2)

Q34 Your computer skills are:

- Poor (1)
- Good (2)
- Very Good (3)
- Excellent (4)

Q35 Have you ever shown other teachers how to use the computer/tablet/laptop?

- Never (1)
- Sometimes (2)
- Quite often (3)
- Always (4)

Q36 How often do you use your computer/tablet/laptop to:

	Never (1)	Less than once a week (2)	Once a week (3)	Several times a week (4)	Once a day (5)	Several times a day (6)
Communicate with others (friends, family, etc) (1)	•	•	•	•	•	•
Surf the web for personal activities (2)	•	•	•	•	•	•
Surf the web for Schoolwork (3)	•	•	•	•	•	•
Go on YouTube (4)	•	•	•	•	•	•
Use the School's website (5)	•	•	•	•	•	•
Use word processing software, like Word (6)	•	•	•	•	•	•
Create a video (7)	•	•	•	•	•	•
Use presentation software, like Power Point (8)	•	•	•	•	•	•
Do some coding (9)	•	•	•	•	•	•
Use the Online Maths Website/s (10)	•	•	•	•	•	•

Q37 How confident do you feel with:

	Not Confident (1)	A bit Confident (2)	Not sure (3)	Confident (4)	Very Confident (5)
Computer and devices (ICT, software and hardware) (1)	•	•	•	•	•
File Management (Organise and storage folders) (2)	•	•	•	•	•
Data protection (3)	•	•	•	•	•
Touch typing (4)	•	•	•	•	•
Printing materials (5)	•	•	•	•	•
Using the Web (6)	•	•	•	•	•
Using E-mails (7)	•	•	•	•	•
Online safety (8)	•	•	•	•	•
Using word processing software, like Word (9)	•	•	•	•	•
Using presentation software, like Power Point (10)	•	•	•	•	•
Using spreadsheets (excel) (11)	•	•	•	•	•
Using text, photo, sound and video editing tools (12)	•	•	•	•	•

Q38 Do you use Online Maths Websites during your teaching in the classroom?

- Yes (1)
- No (2)

Q39 How often do you use Online Maths Websites during a school week time?

- Never (1)
- Once (2)
- Twice (3)
- Three times (4)
- Everyday (5)

Q40 In what way do you use the Online Maths Websites in the classroom?

- Teaching/Demonstration tool (1)
- Student individual activities (2)
- Student group activities (3)
- Whole class activities (4)
- Other (please specify) (5) ____________________

Q41 What are the tools you use the Online Maths Websites on in the classroom?

- Interactive Whiteboard (1)
- Computer (2)
- Laptop (3)
- Tablet (4)
- Whiteboard (5)
- Other (please specify) (6) ____________________

Q42 Do you use the Online Maths Websites to set homework for the students?

- Yes (1)
- No (2)

Q43 How often do students have homework on the Online Maths Websites during a week time?

- None (1)
- Once (2)
- Twice (3)
- Three times (4)
- Every time (5)

Q44 Did you receive training on how to use the Online Maths Website/s?

- Not at all (1)
- Not really (2)
- Undecided (3)
- Somewhat (4)
- Very much (5)

Q45 Who delivered the training?

- ICT coordinator of the school (1)
- Colleague from school (2)
- A friend out of school (3)
- Other (please specify) (4) ____________________

Q46 Where did you find extra support?

- Online (1)
- Other (please specify) (2) ____________________

Q47 How confident do you feel in using the Online Maths Website/s?

- Not confident (1)
- A bit confident (2)
- Not sure (3)
- Confident (4)
- Very confident (5)

Q48 Do you think that the use of the Online Maths Websites prepares students at Year 6 for their computer-based multiplication tests?

- Yes (1)
- No (2)

Q49 Do you use the Online Maths Websites to revise for SATS?

- Yes (1)
- No (2)

Q50 How long do you usually spend on the Online Maths Website/s on a typical day?

- None (1)
- 15 minutes (2)
- 30 minutes (3)
- 1 hour (4)
- 2 hours (5)
- 3 hours (6)
- 4hours (7)
- Over 4 hours (8)

Q51 How often do you use the Online Maths Website/s to:

	Never (1)	Once a week (2)	Several times a week (3)	In every lesson (4)
Teach a concept (1)	•	•	•	•
Inform students' formative assessment (2)	•	•	•	•
Inform the planning of the next lesson (3)	•	•	•	•
Address students' difficulties in specific topics (4)	•	•	•	•
Print students' reports for your use (5)	•	•	•	•
Print students' reports for parents' use and information (6)	•	•	•	•
Set specific individual tasks for different students (7)	•	•	•	•
Set tasks for the whole classroom (8)	•	•	•	•
Use the assessments tool to assign tests to your students (9)	•	•	•	•
Create differentiated learning groups (10)	•	•	•	•
Print Certificates (11)	•	•	•	•
Use Demo tool for whole-class demonstration (12)	•	•	•	•

Q52 If you have made it up to here, please choose the "Strongly agree" option from the options below. This is just a simple attention question! :)

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
Please choose (1)	•	•	•	•	•	•	•

Q54 If you find the survey interesting, please share the link to the survey with your colleagues and any other Primary Teachers you know. To take part in the draw for the £50, please leave your email here and press next to complete the survey and have some more information the purpose of the research! :)

Q55 Debrief

Thank you for taking part in this study. Your contribution is very important to this project!

The last month, I have been collecting information regarding how teachers and students use technologies at home and how they use Online Maths Websites.

According to Prensky (2001), kids nowadays are experts in the use of technology, because they have grown up with it, while people born before 1980s face some struggles with it. Based on that, he argues that today's students require a different teaching and learning approach, which will include novel ways of using technologies even in assessment activities. However, the findings from the first study of the PhD revealed that both teachers' and students' familiarity with technologies vary widely across the classroom and even if the kids nowadays are raised with technologies, when it comes to technologies used in assessment, they are quite sceptical. Primary Schools today use technologies mainly for day to day assessment activities. One of these activities includes the use of online Maths websites, like Mathletics, My Maths and Abacus, where students can find lessons paired with homework for practice and assessment across the curriculum. The aim of this study is to gain a better understanding of how teachers with different digital experiences use the specific websites.

Prensky, M. (2001). Digital natives, digital immigrants part 1. *On the horizon*, 9(5), 1-6.

Appendix E: Descriptive Statistics for studies 2, 3 and 4

1. Descriptive statistics of Study 2

This section presents some descriptive statistics of the participants, the different Online Maths Websites (OMW) that were reported in the questionnaires, the measures of the digital experiences of children, their use of the OMW and their performance of the second study of the thesis.

Online Maths Websites (OMW)

Online Maths Websites used by children

	Percent %
My Maths	31.1
Abacus	29.9
Mathletics	26.6
Abacus and My Maths	6.2
Abacus and Interactive Resources	2.8
My Maths and Interactive Resources	2.3
Abacus and Mathletics	0.6
None	0.6

The Online Maths Websites (OMW) that children reported in the questionnaires were 4; *Abacus, My Maths, Mathletics* and *Interactive Resources*. However, as it is shown on the table above, in some schools the students used more than one OMW. *My Maths* (31.1%) seemed to be the most common website, followed by *Abacus* (29.9%) and *Mathletics* (26.6%). The *Interactive Resources* website was mainly used as a complementary site for Maths tasks, while the other three websites were used for the student's weekly homework.

Children's Self-Reported Digital Experiences

The descriptive statistics for children's digital experiences are presented in relation to the measures used in the questionnaire; *Access, Frequency, Breadth, Confidence*, *Computer skills* and the *Relationships between them*.

Self-reported data: Access

Access to Digital Devices and the Internet

	Yes	No
Internet	98.3	1.1
Tablet	88.1	11.3
Laptop	79.1	20.3
Computer	77.4	22.6
Game Console	65.5	34.5
Mobile Phone	42.9	56.5

According to the data, most of the students have access to many different kind of technologies, with the tablet being the most popular (88.1%), followed by the laptop (79.1%) and the computer (77.4%). Almost all students have access to the Internet at home (98.3%).

Self-reported data: Frequency

Frequency of digital devices' use in a Typical Week Day

	None	1 hour	2 hours	3 hours	Over 3 hours	Total Usage
Tablet	21.5	54.8	15.8	2.3	4	**76.9**
Computer	34.5	52	9.6	2.8	1.1	**65.5**
Laptop	42.9	51.4	2.3	2.8	0	**56.5**
Game console	50.8	37.3	7.3	3.4	1.1	**49.1**
Mobile phone	71.2	20.3	4.5	1.1	2.3	**28.2**

Regarding the frequency of use in a typical weekday, the above table shows that the device that is used the most in total is the tablet with 76.9% of children using it from 1 hour to over 3 hours. The second most used device in a week day is the computer (65.5%), followed by the laptop (56.5%), while it seems that just less than half of the children use the game console (49.1%) in a typical week day. The mobile phone seems to be device with the lowest access and frequency of use (28.2%).

Self-reported data: Breadth

The breadth of uses children are involved in

	Never	Less than once a week	Once a week	Several times a week	Once a day	Several times a day	Total breadth of each use
Play Games	5.1	9.6	22.6	36.2	14.1	12.4	**94.9**
Do your Maths homework	5.6	13	52.5	18.1	5.1	5.6	**94.3**
Surf the web for Schoolwork/ Search information	13.6	23.2	31.1	23.2	5.1	4	**86.6**
Go on YouTube	25.4	16.4	13	19.8	11.9	13.6	**74.7**
Listen to music	23.2	21.5	16.9	19.2	5.6	11.3	**74.5**
Surf the web for fun	35	20.3	18.6	15.3	5.1	5.1	**64.4**
Do other subjects' homework	35	27.7	22.6	6.8	2.8	1.1	**61**
Use Power Point	38.4	35	15.8	4	0.6	2.3	**57.7**

Use the School's website	42.9	26	14.1	9.6	4	1.1	**54.8**
Use Word	45.2	28.8	15.8	5.6	1.1	1.1	**52.4**
Create a video	54.8	23.2	12.4	5.1	1.1	1.1	**42.9**
Chat online (talk with friends)	64.4	9	9	11.3	3.4	2.8	**35.5**
Do some coding	59.9	19.2	7.3	4.5	3.4	0.6	**35**
Collaborate with classmates on a school project	62.7	19.2	9.6	4	0.6	1.1	**34.5**

The table above shows that almost all children use their digital devices in order to play games (94.9%) and do their online Maths homework (94.3%). The uses that follow closely are also related to entertainment and schoolwork, with 86.6% of the children using their digital devices to go on surf the web for schoolwork purposes, 74.7% to go on YouTube, 74.5% to listen to music. The uses that seem to be the least popular amongst children are chatting online with friends (35.5%), coding (35%) and collaborating with classmates (34.5%).

Self-reported data: Confidence

The degree of children's confidence regarding specific tasks on digital devices

	Not Confident	A bit confident	Not sure	Confident	Very confident
Be safe online	4	5.1	10.7	29.4	49.2
Copy and paste text	11.9	7.9	9	21.5	46
Use the camera of the device	13.6	8.5	12.4	22	41.8

Use Power Point	17.5	8.5	7.3	23.2	41.2
Use Word	22	7.9	11.9	18.1	37.9
Print	13	11.9	11.3	27.7	33.9
Assess the information from the Internet	9	14.7	14.7	28.8	29.9
Use the spellchecker	32.2	11.3	9	15.8	28.8
Download files (e.g. Pictures, Games, Music, Videos, animation, text software)	18.1	22.6	16.4	20.9	20.9
Save files in specific folders	24.9	15.3	14.1	23.2	20.9
Create folders	29.9	18.6	16.4	14.1	18.6
Use text, photo, sound and video editing tools	31.6	14.7	14.1	19.2	18.1
Move files to different folders	36.2	18.6	22.6	7.3	12.4
Type fast	20.9	24.9	19.8	22	10.2
Share your ideas online	50.8	13	16.4	7.9	8.5
Use a USB stick	42.4	13.6	17.5	16.4	7.9

Regarding the confidence of children on the different uses of the digital devices, table above shows that almost half of the children reported being very confident being safe online (49.2%) and knowing how to copy and paste text (46%), while the uses that children seem to be not confident at all are related to sharing ideas online (50.8%), using a USB stick (42.4%) and moving files to different folders (48.6%).

Self-reported data: Computer skills

Most of the children that took part in the study reported having Good (37.3%) or Very good (37.3%) computer skills, while 22% of them rated their computer skills as Excellent and only a very small percentage of them reported having poor skills on computers.

Relationships between the measures of Digital Experience

Spearman's rho correlation for the measures of Digital Experience

	Access	Frequency	Breadth	Confidence	Computer skills
Access	1				
Frequency	.137	1			
Breadth	.128	**.485****	1		
Confidence	-.021	**.320****	**.526****	1	
Computer skills	-.029	.148	**.291****	**.521****	1

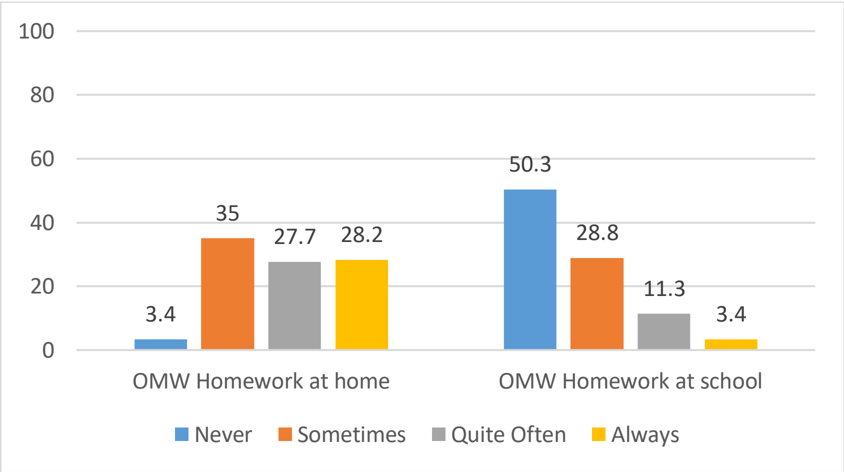
**. Correlation is significant at the 0.01 level (2-tailed).

The table above shows there is no correlation between the children's access to technologies, the breadth of uses, the children's confidence and their computer skills. However, according to the data, there is a medium positive correlation between how often students use the digital devices, the range of different tasks they do (r=.485**, n=152, p<.01) and how confident they are on the use of technologies (r=.320**, N=161, p<.001). In addition, there is a large positive relationship between the breadth of uses on the digital devices and the confidence of the students use technological devices (r=.526**, n=148, p<.01). The breadth of uses is also positively related to the students' computer skills (r=.291**, N=155, p<.01). There is also a significant large positive correlation between how confident students are on the use of the digital devices and the level of their computer skills (r=.521**. N=165, p<.01).

Children's Self Report Use of Online Maths Websites

The descriptive statistics of children's usage of the Online Maths Websites (OMW) as reported by the pupils themselves are presented in the following order; *OMW Frequency, Confidence* and *Performance*.

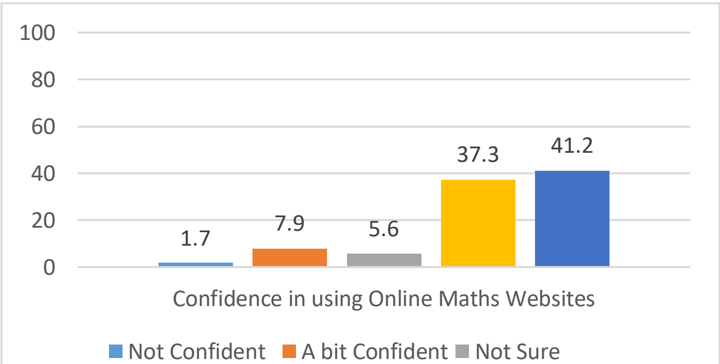
Self-report data: OMW Frequency



Frequency of Online Maths Websites use for homework at Home or School

The figure above shows that most of the children seem to do their online homework at home either Sometimes (35%), Quite Often (27.7%) or Always (28.2%), while only some students do the online homework during the School time or at the After School Clubs Sometimes (28.8%), Quite Often (11.3%) and Always (3.4%).

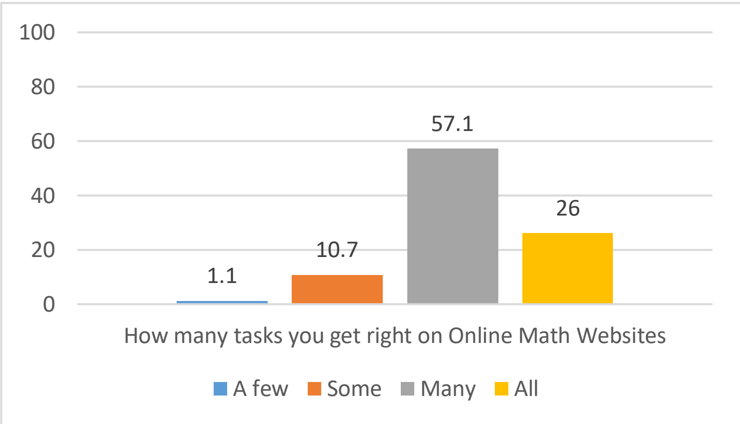
Self-reported data: OMW Confidence



Confidence Using Online Maths Websites

The figure above shows that the majority of the students seem to be Confident and Very Confident (37.3% and 41.2%) on the use of the OMW, while there are also some of them who are a bit confident (7.9%) or not sure (5.6%) and a very small percentage of children who are not confident (1.7%).

Self-reported data: OMW Performance



Performance on Online Maths Websites

The figure above shows that More than half of the children get Many (57.1%), or All (26%) the tasks right on their online homework. There is only a few students who get Some (10.7%) or A few (1.1%) problems right.

2. Descriptive statistics of Study 3

This section presents some of the descriptive statistics for the children's digital experiences in terms of the devices they have access to, the frequency they use these devices during a weekday and weekend, the breadth of different kinds of uses of digital devices, the confidence they have with different functions while using technology and how they evaluate their computer skills. In addition, the descriptive characteristics of students' use of the Online Maths Website; Mathletics, are also presented.

Children's Self-Reported Digital Experiences

The descriptive statistics for children's digital experiences are presented in relation to the measures used in the questionnaire; *Access, Frequency, Breadth, Confidence*, *Computer skills* and the *Relationships between them*.

Self-reported data: Access

Access to Digital Devices and the Internet (%)

	Yes	No
Internet	98.4	1.2
Tablet	89.7	10.3
Game Console	77.5	20.9
Laptop	66.8	32
Mobile Phone	54.9	42.7
Computer	43.9	55.7
Electronic Circuits (Arduino, Raspberry-pi, Makey-Makey, Micro:bit)	4.3	94.9

The table above that most of the students have access to many different kind of technologies, with the tablet being the most popular (89.7%), followed by the game console (77.5%), the laptop (66.8%) the mobile phone (54.9%) and the computer (43.9%), while there is only a very small percentage of students (4.3%) that has access to electronic circuits like Arduino, Raspberry-pi, Makey-Makey and Mirco:bit. Almost all students have access to the Internet at home (98.4%).

Self-reported data: Frequency

Frequency of digital devices' use in a Typical Week Day (%)

	None	15 minutes	30 minutes	1 hour	2 hours	3 hours	Over 3 hours	Total Usage
Tablet	7.5	19.8	9.4	18.6	11.1	2	10.7	**71.6**
Game console	17	13.8	12.6	13.8	8.3	2.8	9.1	**60.4**
Laptop	9.5	21.3	17.8	9.1	3.6	2	3.6	**57.4**
Mobile phone	6.3	13.8	11.9	10.7	3.2	1.6	6.7	**47.9**
Computer	4.3	15	11.5	7.5	2	1.2	2.8	**40**
Electronic circuit	0	0.8	1.6	.08	.08	0	0.8	**1.92**

Regarding the frequency of use in a typical weekday, the table above shows that the device that is used the most in total is the tablet with 71.6% of children using it from 15 minutes to over 3 hours in a typical week day. The second most used device in a week day is the game console (60.4%), followed by the laptop (57.4%), while it seems that just less than half of the children use the mobile phone (47.9%) and even less the computer (40%) in a typical week day. The electronic circuit seems to be the category of devices with the lowest access and frequency of use (1.92%).

Self-reported data: Breadth

The breadth of uses children are involved in (%)

	Never	Less than once a week	Once a week	Several times a week	Once a day	Several times a day	Total breadth of each use
Play Games	3.2	7.1	13	28.9	12.6	31.6	**93.2**
Do your Maths homework	4.3	6.7	47.4	19	9.1	10.7	**92.9**
Go on YouTube	9.1	9.9	8.7	16.6	12.6	40.7	**88.5**
Do other subjects' homework	8.7	9.9	36.4	23.7	9.5	8.3	**87.8**
Surf the web for Schoolwork/ Search information	11.9	16.6	28.9	22.1	10.7	7.9	**86.2**
Listen to music	12.6	13.8	19.8	14.2	9.5	26.9	**84.2**
Chat online (talk with friends)	36.4	11.5	11.5	13.8	8.3	14.6	**59.7**
Surf the web for fun	35.2	9.9	16.6	11.1	4.7	7.1	**49.4**
Use the School's website	49.8	16.2	13	7.1	5.5	4.3	**46.1**

Create a video	53.4	14.6	14.6	4.3	3.6	6.7	**43.8**
Use Word	57.7	15	7.5	6.7	1.2	5.1	**35.5**
Use Power Point	67.2	13	7.1	2	1.6	2.4	**26.1**
Collaborate with classmates on a school project	76.3	9.5	4.7	1.2	1.6	3.2	**20.2**
Do some coding	78.7	5.5	3.6	1.6	2	2.8	**15.5**

The table above shows that almost all children use their digital devices in order to play games (93.2%) and do their online Maths homework (92.9%). The uses that follow closely are also related to entertainment and schoolwork, with 88.5% of the children using their digital devices to go on YouTube, 87.8% to do other subjects' homework, 86.2% to search information for schoolwork and 84.2% to listen to music. The uses that seem to be the least popular amongst children are the collaboration with classmates (20.2%) and coding (15.5%).

Self-reported data: Confidence

The degree of children's confidence regarding specific tasks on digital devices (%)

	Not Confident	A bit confident	Not sure	Confident	Very confident
Use the camera of the device	7.5	5.9	5.5	21.3	56.1
Be safe online	3.2	2.8	7.5	26.1	56.1
Assess information from the Internet	19	16.2	14.2	18.6	28.5
Use text, photo, sound and video editing tools	20.9	14.2	10.3	25.7	25.7
Copy and paste text	30.4	13	11.1	16.6	25.3
Print	26.9	16.2	10.7	17.8	22.5
Use the spellchecker	32.8	13.4	11.9	15.4	22.5
Type fast	17.4	18.6	14.6	24.1	22.1
Use Word	37.5	9.1	7.9	19.4	22.1
Download files (e.g. Pictures, Games, Music, Videos, animation, text software)	20.9	18.2	18.6	22.1	17
Use a USB stick	47.4	11.9	11.9	9.1	16.2
Use Power Point	40.3	16.2	14.6	10.3	14.2
Create folders	34.4	20.2	14.2	14.6	13
Move files to different folders	48.6	13.8	15.8	7.5	10.7
Share your ideas online	50.2	13	11.9	10.3	10.3
Save files in specific folders	36	20.9	17	14.2	7.1

Regarding the confidence of children on the different uses of the digital devices, **Error! Reference source not found.**shows that more than half of the children reported being very confident using the camera on their devices (56.1%) and being safe online (56.1%), while the uses that children seem to be not confident with at all are related to sharing ideas online (50.2%), moving files to different folders (48.6%) and using a USB stick (47.4%).

Self-reported data: Computer skills

Most of the children that took part in the study rated their computer skills as being excellent (37.9%), while the rest rated them as Good (29.2%) or Very Good (28.5%) and only a very small percentage of them believed they had poor computer skills (2.8%).

Relationships between the measures of Digital Experience

Spearman's rho correlation for the measures of Digital Experience

	Access	Frequency	Breadth	Confidence	Computer skills
Access	1				
Frequency	**.451****	1			
Breadth	**.314****	**.390****	1		
Confidence	**.324****	**.419****	**.432****	1	
Computer skills	**.143***	**.310****	**.300****	**.359****	1

**. Correlation is significant at the 0.01 level (2-tailed).

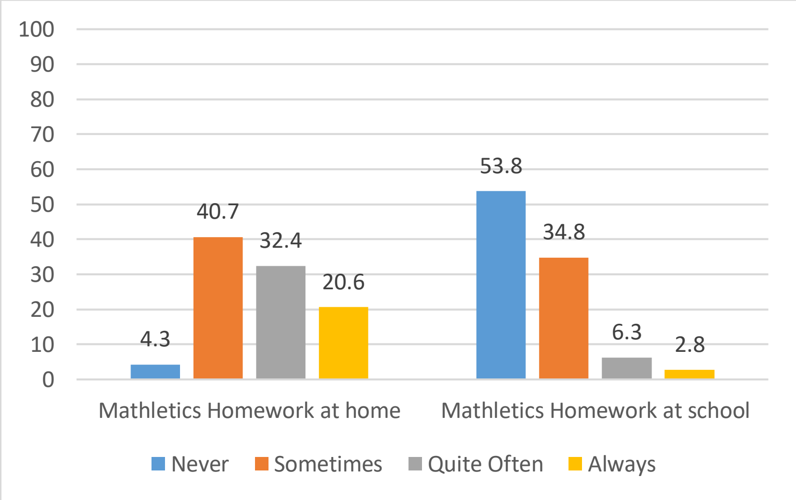
*. Correlation is significant at the 0.05 level (2-tailed).

The table above shows that all the measures of children's digital experiences are linked to each other with positive moderate correlations. More specifically, it seems that the more children have access to technologies, the more often they use them (r=.451**, p<.01), the wider the breadth of uses is (r=.314**, p<.01), the more confident they are (r=.324**, p<.01), and also, according to a weaker positive correlation, the better computer skills they have (r=.143*, p<.05). In the same way, the more often children use technologies, the wider the breadth of uses is (r=.390**, p<.01), the more confident the children are (r=.419**, p<.01) and the better computer skills they have (r=.310**, p<.01). Regarding the breadth of uses, the wider children use technologies, the better their confidence (r=.432**, p<.01) and their computer skills are (r=.300**, p<.01). Finally, the more confident children are on using technology, the better the computer skills they have (r=.359**, p<.01).

Children's Self Report Use of Mathletics

The descriptive statistics of children's usage of Mathletics as reported by the pupils themselves are presented in the following order; *OMW Frequency, Confidence* and *Performance*.

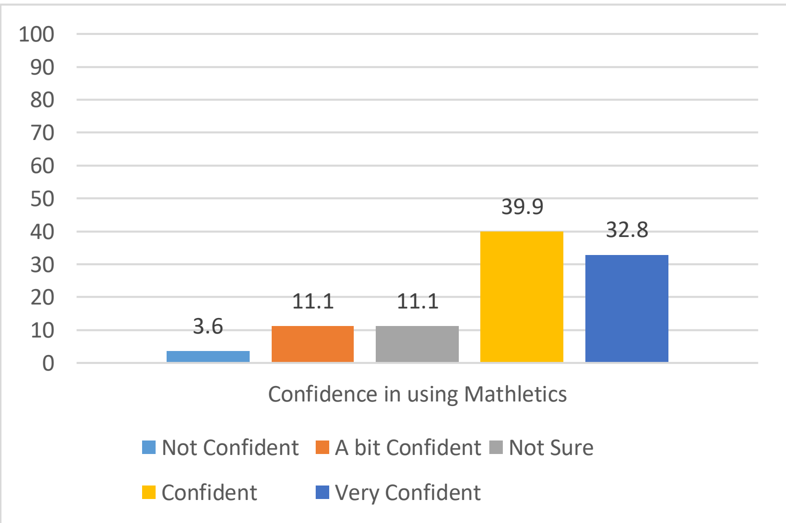
Self-report data: OMW Frequency



Frequency of Mathletics homework at Home or School

The table above shows that most of the children seem to do their online homework at home either Sometimes (40.7%), Quite Often (32.4%) or Always (20.6%), while only some students do the online homework during the School time or at the After School Clubs Quite Often (6.3%) and Always (2.8%).

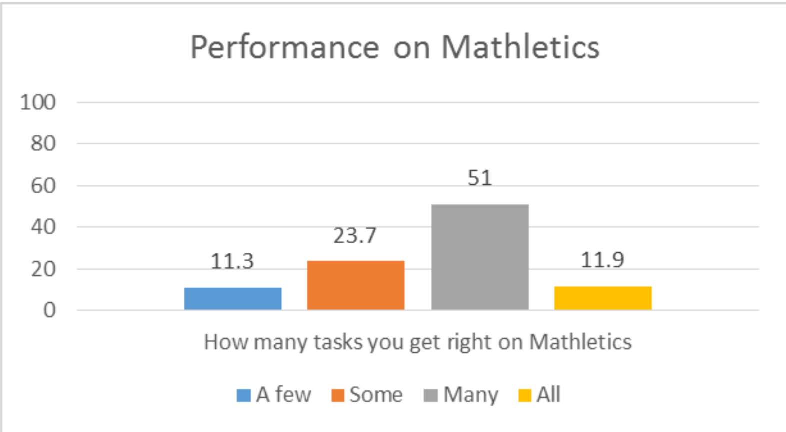
Self-reported data: OMW Confidence



Confidence Using Mathletics

The figure above shows that most of the children reported that they feel Confident (39.9%) and Very Confident (32.8%) using the online website Mathletics, while only a very small percentage of them said they don't feel confident (3.6%).

Self-reported data: OMW Performance



Performance on Mathletics

The figure above shows that just over half of the children report get Many (51%) tasks right, while the rest will get either Some (23.7%) or All (11.9%) of the tasks right and only a small percentage (11.3%) gets only a few activities correct.

Children's Usage data from Mathletics

The descriptive frequencies of the actual usage measures gathered from the Mathletics archive are presented with the following order; *Activity Average Improvement, Signs-ins, Time online, Attempts, Number of Activities*, and *Activities completed at school* and *at home* and the *Relationships* between them.

Mathletics data: Average Improvement

As mentioned above, 253 pupils took part in the study. Of these, the data of 196 children (77.47%) revealed a change in their performance (either positive or negative), while 57 pupils (22.53%) had no change. Of the pupils who had a change in their performance, 177 (69.96%) had a positive change and they improved their average performance, while only 19 (7.5%) of them had a negative change. Of the children who had a positive improvement in their performance, 28.1% made an improvement of 1-10% since the beginning of the school year (September 2016), 31.2% of them made an improvement of 10-20%, while 10.7% of the children made an improvement of more than 20%.

Mathletics data: Sign-ins

It seems that almost half of the children sign in to Mathletics once per week (42.3%), while some of them don't sign in at all (23.3%). Some children sign in twice per week (20.6%) and others 3 times or more (13.9%).

Mathletics data: Time online

The time online was taken from the website regarding the time children had spent on Mathletics the week before they completed the questionnaire. There were an equal amount of children who spent either no time (23.3%) on Mathletics, or from 1 to 10 minutes (23.3%). The rest of the children spent 11 - 20 minutes (16.6%), 21-30 (10.7%), 31-40 (7.9%), 41-50 (4%), 51-60 (4.3%), while some of them spent more than 1 hour (9.9%) on Mathletics in a week.

Mathletics data: Attempts

Just under half of the children make an average of more than 2 attempts (46.2%) for the tasks they try online, while 36.8% of them try each task only once and 17% try once or a maximum twice on each task.

Mathletics data: Number of Activities and Number of Activities completed at home and school

Most of the children had completed between 14-50 activities (68.8%) from September to March, while 25.7% of them had completed 50-100 activities and there were a small percentage of children who had completed over 100 activities in this period of time (5.5%).

Regarding the activities being completed at home versus school, it seems that almost all of the children (99.2%) had completed their activities at home, while only 0.8% of them had never completed any tasks at home. In the case of school, 33.2% of the children had never completed any activities at school, while the rest 66.8% had done at least some of their activities at school during September to March.

Relationships between data from Mathletics

Spearman's rho correlation between data from Mathletics

	Activity Average Improvement	Sign ins	Time online last week	Attempts	Number of Activities	Activities completed at school	Activities completed at home
Activity Average Improvement	1.000						
Sign ins	.023	1.000					
Time online last week	.021	**.819****	1.000				
Attempts	-.072	**.334****	**.299****	1.000			
Number of Activities	-.097	**.506****	**.450****	**.623****	1.000		
Activities completed at school	-.034	**.219****	**.255****	.107	**.348****	1.000	
Activities completed at home	-.106	**.490****	**.448****	**.749****	**.930****	**.196****	1.000

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

The table above shows that the activity average improvement is not linked to the way children use the website based on the data from the website. However, the rest of the measures regarding what children do when they are using the website are all linked positively to each other, as the more a child uses the website, the more time they will spend on it, the more attempts and number of activities they will complete. For example the more sign-ins children have, the more time they will spend online as well (r=.819**, p<.01).

3. Descriptive statistics of study 4

The results section presents some of the descriptive statistics (in percentages) in relation to the teachers' digital experiences and their use of the Online Maths Websites. The section continues with testing of the hypotheses exploring the relationships between the age of teachers, their digital experiences, their use of the Online Maths Websites and their training.

Teachers' Digital Experiences

The descriptive statistics for teachers' digital experiences are presented in relation to the measures used in the questionnaire; *Access, Frequency, Breadth, Confidence*, *Computer skills* and the *Relationships between them*.

Self-reported data: Access

Access to Digital Devices and the Internet (%)

	Yes	**No**
Mobile Phone	100	0
Internet	99.05	0.95
Laptop	85.05	14.95
Tablet	72.9	27.1
Computer	49.53	50.47
Game Console	35.51	64.5
Electronic Circuits (Arduino, Raspberry-pi, Makey-Makey, Micro:bit)	6.54	93.46

The table above shows that most of the teachers have access to many different kind of technologies, with the mobile phone being the device that every teacher has (100%), followed by the laptop (85.05%), the tablet (72.9%), the computer (49.53%) and the game console (35.51%), while there was only a very small percentage of teachers (6.54%) who have access to electronic circuits like Arduino (0%), Raspberry-pi (5.61%), Makey-Makey (0%) and Mirco:bit (0.93%) at home. Regarding Internet access, it seems that almost all of the teachers have access to the Internet at home (99.05%), apart from 1.

Self-reported data: Frequency

Frequency of digital devices' use in a Typical Week Day (%)

	None	**15 minutes**	**30 minutes**	**1 hour**	**2 hours**	**3 hours**	**4 hours**	**5 hours**	**Over 5 hours**	**Total usage**
Mobile phone	0.95	18.10	14.29	**28.57**	21.90	5.71	2.86	1.90	5.71	**99.04**
Computer	9.62	1.92	13.46	**25**	**25**	9.62	5.77	1.92	7.69	**90.38**
Tablet	12.99	12.99	16.88	**29.87**	12.99	7.79	2.60	1.30	2.60	**87.02**
Laptop	18.89	6.67	13.33	**26.67**	15.56	8.89	4.44	1.11	4.44	**81.11**
Electronics	71.43	**14.29**	0	**14.29**	0	0	0	0	0	**28.58**
Game console	86.49	**8.11**	2.70	2.70	0	0	0	0	0	**13.51**

The table above shows that the mobile phone is the device that has the highest score in total usage with 99.04% of the teachers using their mobile phones from 15 minutes to 5 hours or more in a typical weekday. The second most used device for teachers is the computer (90.38%) followed by the tablet (87.02%) and the laptop (81.11%), while digital devices like the electronics (28.58%) and game consoles (13.51%) have a much lower rate of total usage and a maximum length of 1 hour for a typical weekday. Almost half of the teachers seem to use their mobile phones and computers between 1 and 2 hours, their tablet and laptop for approximately 15 minutes to 2 hours, while the game console and the electronics do not seem to be used in a teacher's typical weekday at all.

Self-reported data: Breadth

The breadth of uses teachers are involved in (%)

	Never	Less than once a week	Once a week	Several times a week	Once a day	Several times a day	Total breadth of each use
Surf the web for Schoolwork/ Search information	0.95	0.95	2.86	32.38	19.05	**43.81**	**99.05**
Surf the web for personal activities	0.95	1.9	11.43	26.67	21.9	**37.14**	**99.04**
Use word processing software (like Word)	1.9	3.81	4.76	18.1	20	**51.43**	**98.1**
Use presentation software (like Power Point)	1.9	24.76	10.48	**32.38**	15.24	15.24	**98.1**
Go on YouTube	2.86	22.86	15.24	**35.24**	16.19	7.62	**97.15**
Communicate with others (friends, family, etc)	3.81	9.52	6.67	22.86	13.33	**43.81**	**96.19**
Use the School's website	7.62	**35.24**	19.05	17.14	12.38	8.57	**92.38**
Use the Online Maths Website/s	8.57	20.95	20	**33.33**	9.52	7.62	**91.42**
Create a video	42.86	**48.57**	4.76	0	1.9	1.9	**57.13**
Do some coding	**53.33**	30.48	7.62	5.71	0.95	1.9	**46.66**

The table above shows what teachers do more often on their digital devices during a week. It seems that almost all of the teachers use their devices from less than once a week to several times a day in order to surf the web for schoolwork (99.05%) or personal activities (99.04%) and use word processing and presentation software (98.1%). The next most popular uses amongst teachers are going on YouTube (97.15%) and communicating with others (96.19%) during the week. The use of the school's website (92.38%) and the online maths websites (91.42%) are also used in quite high percentages. However, there is a quite distinctive drop in the percentages in terms of how often they create a video (57.13%) and do some coding (46.6%).

The most common use amongst the teachers is Word processing software which is used several times a day (51.43%), followed by communication with others (43.81%), surfing the Web for school work (43.81%) and for personal activities (37.14%). Other uses that are less often, but still teachers would do them more than once time a week are to go on YouTube (35.24%), use the OMWs (33.33%) and use a presentation software (32.38%). The rarest uses were coding (53.33%) and the creation of videos (42.86%).

Self-reported data: Confidence

The degree of teachers' confidence regarding specific tasks on digital devices (%)

	Not Confident	A bit confident	Not sure	Confident	Very confident
Using word processing software (like Word)	0.95	0.95	0	42.86	**55.42**
Using the Web	0.95	0	0.95	44.76	**53.33**
Using E-mails	.095	0	0.95	44.76	**53.33**
Computer and devices (ICT, software and hardware)	2.86	16.19	1.9	**55.24**	23.81
Printing materials	1.9	2.86	2.86	**54.29**	38.1

File Management (Organise and storage folders)	0.95	6.67	8.57	**52.38**	31.43
Online safety	0.95	5.71	2.86	**51.43**	39.05
Using presentation software (like Power Point)	0.95	1.9	1.9	**50.48**	44.76
Data protection	2.86	22.86	14.29	**48.57**	11.43
Using spreadsheets (like Excel)	9.52	12.38	13.33	**48.57**	16.19
Use text, photo, sound and video editing tools	6.67	18.1	12.38	**47.62**	15.42
Touch typing	12.38	19.05	9.52	**35.24**	23.81

Regarding the confidence of teachers with the different uses of digital devices, it seems that most teachers are either confident or very confident. More specifically, teachers reported being very confident while using word processing software (55.24%) and using the Web and sending e-mails (53.33%), while they are confident while using computer and devices (ICT, software and hardware) in general (55.24%), printing materials (54.29%), managing files (52.38%), being safe online (51,43%) and using presentation software (50.48%).

Self-reported data: Computer skills

Most of the teachers that took part in the study rated their computer skills as being Good (39.05%), while the rest rated them as Very Good (36.19%) or Excellent (22.86%) and only a very small percentage of them believed they had poor computer skills (1.9%).

Relationships between the measures of Digital Experiences

Spearman's rho correlation for the measures of Digital Experience

	Access	Frequency	Breadth	Confidence	Computer skills
Access	1				
Frequency	**.430****	1			
Breadth	.041	**.381****	1		
Confidence	.108	**.383****	**.427****	1	
Computer skills	.092	**.404****	**.330****	**.548****	1

**. Correlation is significant at the 0.01 level (2-tailed).

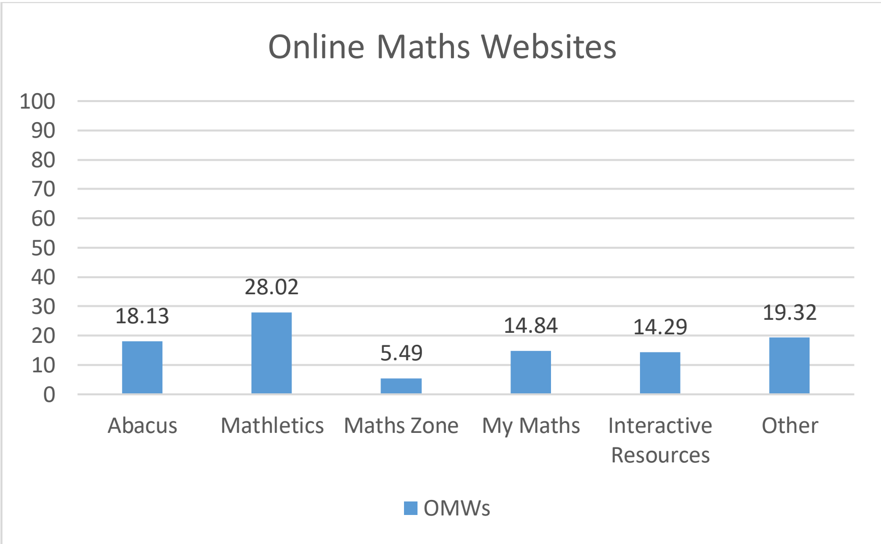
The table above shows that almost all the measures of teachers' digital experiences are linked to each other with positive moderate correlations apart from the access with the breadth, confidence and computer skills. More specifically, it seems that the more teachers have access to technologies, the more often they use them (r=.430**, $p<.01$). In a similar way, the more often teachers use technologies, the wider the breadth of uses is (r=.381**, $p<.01$), the more confident they are (r=.383**, $p<.01$) and the better computer skills they have (r=.404**, $p<.01$). Regarding the breadth of uses, it seems that the wider teachers use technologies, the better their confidence (r=.427**, $p<.01$) and their computer skills are (r=.330**, $p<.01$). Finally, the more confident teachers are using technology, the better the computer skills they have (r=.548**, $p<.01$).

Teachers' Use of Online Maths Website (OMWs)

The descriptive statistics for teachers' usage of OMWs are presented in the following order; *basic characteristics of OMW usage; OMW Frequency, OMW Breadth, OMW Confidence, OMW Time Online, OMW Training*.

Basic Characteristics of OMW usage

In order to understand the relationships between the digital experiences of teachers and their use of the Online Maths Websites better, it is also important to report some of the basic characteristics regarding how teachers use OMWs, like which websites they use, how much experience they have working on them, which school years are the ones they are using them the most.



Online Maths Websites

The figure above shows that the most popular website amongst the teachers that took part in the survey is Mathletics (28.02%), followed by the option Other (19.32%) and Abacus (18.13%). The option Other included websites like, NRich, White Rose, Top marks, Maths Watch VLE, Schools own site, IXL, Hit the button, RM Easimaths, Doodle maths, ICT games, Espresso Maths resources, Twinkl, TES, TESiboard, Activelearn, Sumdog, Maths no problem, My own developed resources, Education city, Maths whizz, Passport maths, Number gym, Maths is fun, and a range of others chosen to suit particular topic.

Regarding teachers' experience working on these kind of websites, most of the teachers reported that they have been using OMWs for 1 year (22.22%), while many of them have worked with OMWs either 3 years or more than 4 years (18.52%). However, there are also a few teachers who have only a few months of experience working with OMWs (15.74%). In addition to that, it seems that teachers use OMWs mainly for the year groups of Key Stage 2 (Year 3, 37.96%; Year 4, 43.52%; Year 5, 54.83%; Year 6, 48.15%), with Year 5 being the group that use OMWs the most. The foundation Years 1 (26.85%)

and 2 (33.33%) still use maths websites, but not to the same extent as the rest of the year groups.

The main ways teachers choose to use OMWs include using them as a teaching/demonstration tool (82.5%), to set whole class activities to the pupils (66.25%) and give activities to individual pupils (57.5%), while there were a smaller percentage of 41.25% teachers who use the OMWs to set group activities to their pupils. Teachers use the OMWs mainly on the classroom's interactive whiteboard (91.25%), while approximately half of them use it on computers (51.25%), laptops (41.25%), tablets (37.5%), or a simple whiteboard (28.75%).

OMW Frequency

Of the teachers who took part in the survey, 76.19% said they use OMWs during their teaching in the classroom, while the rest 23.81% said they do not use them in their classroom. Most of the teachers who use OMWs in their classroom do that either once or twice during a week (27.50%), while the rest of them seem to use it either everyday (23.75%) or twice (21.25%) a week. Regarding homework, 67.31% of teachers reported that they use the OMWs to set homework for their pupils, while 32.69% of them said they do not use the websites for homework purposes. Most of the teachers who use the website to set homework for their students would set it only once (87.14%) per week, while others would use it twice (7.14%), every time (2.88%) or three times per week (1.43%).

OMW Breadth

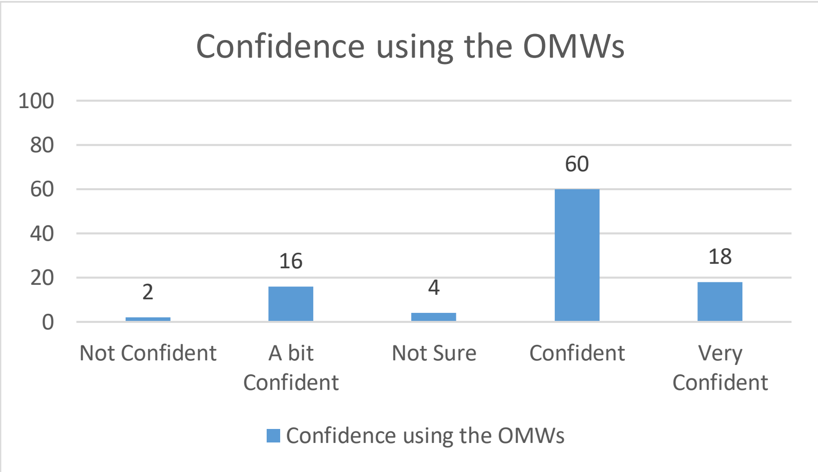
Breadth of uses on OMWs (%)

	Never	Once a week	Several times a week	In every lesson	**Total breadth of each use**
Set tasks for the whole classroom	23	**49**	26	2	**77**
Teach a concept	31	**35**	30	4	**69**

Address students' difficulties in specific topics	31	**41**	27	1	**69**
Use demo tool for whole-classroom demonstration	**40**	32	24	4	**60**
Inform the planning of the next lesson	**42**	32	24	2	**58**
Set specific individual tasks for different students	**43**	39	17	1	**57**
Inform students' formative assessment	**47**	40	12	1	**53**
Use the assessments tool to assign tests you our students	**58**	30	11	1	**42**
Create differentiated learning groups	**60**	25	14	1	**40**
Print certificates	**72**	20	7	1	**28**
Print students' reports for your use	**78**	14	7	1	**22**
Print students' reports for parents' use and information	**80**	10	9	1	**20**

The table above shows that the most common use of the OMWs amongst teachers during a school week time in total is to set tasks for the whole classroom (77%), followed by the use of teaching a concept and addressing students' difficulties in specific topics (69%), while the least common use of the OMWs is to print students' reports either for their own use (22%) or for the parents' information (20%).

OMW Confidence



Confidence using OMW

The figure above shows that more than half of the teachers reported being confident (60%) on the use of the OMWs, while a smaller percentage of them said they are very confident (18%) and a bit confident (16%), leaving only a few of them that are either not sure (4%) or not confident (2%).

OMW Time Online

Regarding the time teachers usually spend on the OMWs on a typical day, it seems that most of them spend around 15 minutes (40%), 30 minutes (25%), or no time at all (21%), while there is also a lower percentage of teachers who would spend 1 hour (13%) or 4 hours (1%) on the OMWs.

Relationships between the measures of OMW use

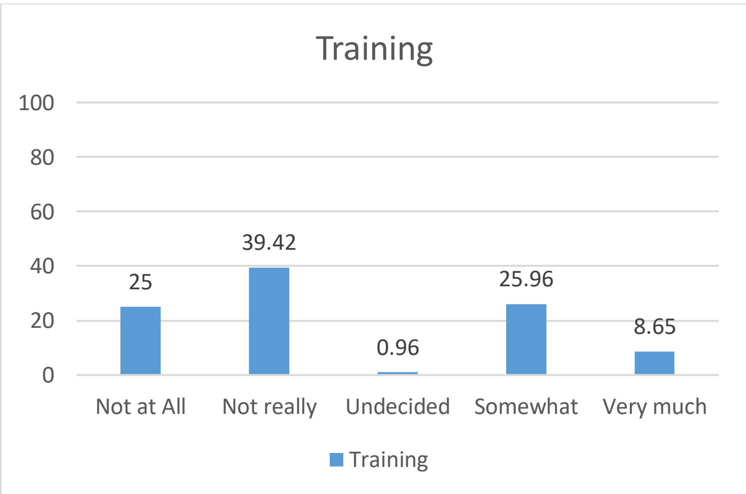
Spearman's rho correlation between the measures of the OMWs use

	OMW Frequency	OMW Breadth	OMW Confidence	OMW Time online
OMW Frequency	1.000			
OMW Breadth	-.051	1.000		
OMW Confidence	.074	.130	1.000	
OMW Time online	-.104	**.670****	.094	1.000

**. Correlation is significant at the 0.01 level (2-tailed).

The table above shows that there is only one significant, strong correlation between the measures of teachers' OMWs use. It seems that the time teachers spend on the OMWs is positively correlated to the breadth of the websites' uses (r=.670**, p<.01), which could mean that the more time they spend on the websites, the wider the range of uses is.

OMW Training



Training that Teachers received regarding the use of OMWs

According to the figure above, some of the teachers reported that they did not really receive training on how to use OMWs (39.42%), while most of them said they had somewhat kind of training (25.96%) or not at all (25%). There is only a very small percentage of teachers who seemed to have received very much training (8.65%). In half of the cases, the training teachers received came from a colleague from school (50%), while other teachers said they received training from the ICT coordinator of their school (22.09%) or from somewhere else (25.58%). The option somewhere else/other included cases like, Mentor, a representative from the provider (Mathletics, Abacus, Doodle Maths, Maths Wizz, Active Learn), someone from National Numeracy and Self-taught. A very small percentage of teachers also reported that they found help from a friend out of school (2.33%). The most common response regarding where they would find extra support in case needed seemed to be online (73.08%) or other (26.92%) including Maths leaders of the schools, colleagues, or on the phone with the provider.